The University of Chicago

GEOLOGY AND MINERAL RESOURCES OF THE JOLIET QUADRANGLE

A DISSERTATION

SUBMITTED TO THE FACULTY
OF THE OGDEN GRADUATE SCHOOL OF SCIENCE
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

DEPARTMENT OF GEOLOGY

By
DANIEL JEROME FISHER

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
A. M. SHELTON, Director

DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, Chief

Reprinted from
BULLETIN NO. 51

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Fig. 1. Index map of Illinois showing the location of the Joliet quadrangle.

GEOLOGY AND MINERAL RESOURCES OF THE JOLIET QUADRANGLE

By D. J. Fisher

CHAPTER I—INTRODUCTION

Location and Extent of the Area

The Joliet quadrangle, located in northeastern Illinois, includes the northwestern part of Will County and a small portion of western Cook and southern DuPage counties (fig. 1). The city of Joliet in its southeastern corner is about 35 miles southwest of Chicago. The map covers an area of approximately 221 square miles, with a north-south length of over 17 miles, and an east-west width of almost 13 miles. The scale is approximately one mile to the inch. This map is a part of a large topographic map which the United States Geological Survey is preparing of the United States, and for convenience, in most areas this large map is divided into units or quadrangles 15′ of latitude by 15′ of longitude. The Joliet quadrangle lies between parallels 41°30′ and 41°45′ and meridians 88°00′ and 88°15′ (Pl. I).

Purpose and Scope of the Report

It has been the aim of the writer in this report to present the geological history of the area in language intelligible to the educated layman. It is hoped that the material herewith presented will not only enable operators to proceed economically in the development of the mineral resources of the district, but will also serve as a guide to the people of the area who are interested in its past history.

Field Work and Acknowledgments

The field work upon which this report is based was done in the summer of 1921, with Mr. W. A. Dawson as field assistant. This opportunity is taken to acknowledge the help given by the inhabitants of the area, for without the well records, most of which were supplied by the farmers, the information would have been much less detailed. Doctor M. M. Leighton, Chief of the State Geological Survey, has particularly placed the writer in his indebtedness, not only for actual aid in field work, but for additional advice and assistance. Mr. F. W. DeWolf, former Chief of the Survey, spent two days in the field, and other members of the Survey have generously given assistance of various kinds. The late Professor R. D. Salisbury of the University of Chicago spent a day in the field, critically read the manuscript, and gave much valuable aid. Professor Stuart Weller, Mr. A. W.

Slocom, and others of the University of Chicago, have been of much assistance. Mr. F. C. Baker of the University of Illinois not only determined the Pleistocene fossils, a list of which appears in the latter part of the report, but also interpreted the origin of the enclosing deposits on the basis of the fossil evidence. Professor T. E. Savage of the University of Illinois confirmed the determination of some of the Silurian fossils. While all available sources have been drawn on, special acknowledgment is due the writers of the publications listed in the bibliography. Mrs. D. J. Fisher gave invaluable aid in the preparation of the manuscript.

CHAPTER II—TOPOGRAPHY

Drainage

The Joliet quadrangle lies near the northeastern border of the Mississippi basin, only a few miles from the divide between it and the Great Lakes-St. Lawrence drainage system. The area is drained by Des Plaines River and its tributaries, of which Du Page River, flowing south through the western half of the quadrangle, is the largest. Des Plaines River has its source in southeastern Wisconsin, crosses the southeastern part of the Joliet quadrangle and, continuing southwest, is joined by Du Page River about 10 miles below Joliet. About four miles farther downstream, it unites with Kankakee River coming from the southeast, and the two rivers form Illinois River which flows in a general southwesterly direction to the Mississippi at Grafton, approximately 40 miles above St. Louis.

The more important tributaries joining Des Plaines River within the Joliet area are Long Run, an unnamed creek just north of Lockport, and Fraction Run in T. 36 N., R. 10 E., Spring and Hickory creeks, and Sugar Run, in T. 35 N., R. 10 E., all of which lie to the east of the Des Plaines, a phenomenon which is readily explained in the light of the glacial history of the region (Chapters V and VI). Rock Run in the southwestern part of the quadrangle, T. 35 N., R. 9 E., once joined the Des Plaines about four miles below Joliet, but now flows into the Illinois and Michigan Canal.

Du Page River, which is formed near the north edge of the quadrangle, T. 37 N., R. 10 E., by the junction of East and West branches, has Spring Brook, T. 37 N., R. 9 E., and Lilly Cache Creek, T. 36 N., R. 9 E., of which Mink Creek is a minor tributary, as its more important tributaries.

Relief

The maximum relief of the quadrangle is slightly less than 300 feet, the surface being below the 510 contour where the Des Plaines flows off the map, and above the 790 contour near the east edge of the map northeast of Lockport, and also in the northeast corner of the quadrangle The maximum local relief is found near East Branch of Du Page River and along the Des Plaines valley, especially near Joliet, where cliffs tend to make the valley a major topographic feature.

Three great sloughs, broad abandoned valleys which were obviously at some past time occupied by good-sized rivers, are other notable topographic features. These cross the central part of the quadrangle in a general east-west direction, roughly parallel and 2 to 3 miles apart (Pl. I). The

southern one, Rock Run slough, is the most pronounced of the three, and lies mainly in the southwestern part of Lockport Township, T. 36 N., R. 10 E. Mink Creek slough, the least well-defined, is in northwestern Lockport Township, and Lilly Cache slough is in southwestern DuPage Township, T. 37 N., R. 10 E.

Ridges or "spoil banks" (fig. 47) miles in length and more than 50 feet in height, composed of blocks of dolomite excavated from the site of the Chicago Drainage Canal, flank both sides of the canal, serving to break the level of the broad valley flat, which, in many places more than a mile in width, is now occupied by the diminutive Des Plaines River.

Culture

Except for the city of Joliet with its population of 38,442, census of 1920, exclusive of the large population in the suburbs, the quadrangle comprises a fairly typical, well-developed, thickly-settled rural area of northeastern Illinois. Lockport and Lemont, a small part of which lies within the quadrangle, are small cities of about 2,500 each. Plainfield and Rockdale are villages of about 1,300 each. Little of the area is covered by forest except the slopes along certain water courses, and three parks near Joliet. Excluding these and a few small areas near the northern and eastern edges of the quadrangle, nearly all of the land is devoted to crops or pasture.

The roads, which commonly run along the section lines, are largely graveled owing to the great abundance of this material. The Lincoln Highway running through Joliet and Plainfield, and the Lone Star Route from Joliet to Lemont are mainly concrete and macadam. The area is served by both electric and steam transportation. The Santa Fe, and the Chicago and Alton railroads are in the Des Plaines Valley. The Chicago, Rock Island and Pacific and the Michigan Central railroads come into Joliet down the valley of Hickory Creek. The Elgin, Joliet and Eastern Railroad, which carries freight only, joins Joliet with Aurora and Elgin to the northwest, and Chicago Heights to the east. It also has a line running near the western edge of the quadrangle between West Chicago and Minooka. The Chicago, Milwaukee and Gary railroad comes into Joliet from Momence and the southeast. Electric lines connect Joliet with Lockport, Lemont, and Chicago up Des Plaines Valley, with Morris and other towns down this valley, and with Plainfield and Aurora to the northwest.

CHAPTER III—BED ROCK FORMATIONS

Introduction

In general, the geologist can not use years or centuries in stating the age of a deposit. There is no way of measuring the exact time which has elapsed since the deposition of most formations in these terms, but an approximate idea may be gained by a study of geologic processes now in operation, the thickness of sediments which have been laid down in times past, the amount of change which they exhibit, the amount of change which the life of the earth has undergone, and other phenomena which need not be mentioned here. From a study of the external relations of the rocks, as well as from a study of their composition, structure, fossil content, and other features, it has been found that time and again considerable portions of our continents have been depressed below sea level and received great thicknesses of sediments, and subsequently have been uplifted and degraded by erosive agencies.

On the basis of the geologic history of widely scattered districts, the following subdivisions of geologic time have been made.

Table 1.—*Subdivisions of geologic time*

Era	Period
Cenozoic (Modern life) (Age of mammals)	Recent
	Pleistocene
	Pliocene
	Miocene
	Oligocene
	Eocene
Mesozoic (Medieval life) (Age of reptiles)	Cretaceous
	Comanchean
	Jurassic
	Triassic
Paleozoic (Old life)	Permian
	Pennsylvanian
	Mississippian
	Devonian
	Silurian
	Ordovician
	Cambrian
Proterozoic (Older life)	
Archeozoic (First life)	

The eras were not of equal duration; in general the earlier ones were longer than the later ones. The Paleozoic has been estimated to have been twice as long as the Mesozoic, which was perhaps three times as long as the Cenozoic. It has been aptly said that the geologist cannot estimate the age of the earth in centuries as closely as the botanist can tell the age of the giant California redwood trees in seconds. Barrell[1] estimates that the beginning of the Cambrian was between 550,000,000 and 700,000,000 years ago.

The bed rocks found in the Joliet area, including those encountered in wells, consist of limestones (calcium carbonate), dolomitic limestones (rocks similar to limestones but containing some magnesium carbonate in place of part of the calcium carbonate), shales (mud rocks) and sandstones. All of these rocks are stratified or bedded, and lie more or less horizontally, as seen in quarries and rock cliffs. Bedded rocks of this type, where the bedding is more or less parallel for long distances, were deposited in standing water, and from this it is known that the Joliet area was in times past under water. That this water was sea water rather than fresh water, is demonstrated by the type of fossils found in these rocks.

Sands are now being deposited on and near the shore of the ocean where the water is shallow, and where there is a nearby land mass which is being eroded by active rivers. Cementation of these sands produces sandstone, such as is met in the drilling of wells. Farther out from such a land mass, or near a very low-lying one, muds are now forming, which, if indurated, would produce shales. Where the waters are clear and other conditions are suitable, sediments composed of calcareous muds, oozes, and shells are forming, which, by cementation, may be converted into limestone. Thus the conditions under which sediments form are more or less characteristic for each type, and from a study of the sediments the geologist is able to deduce something of the past history of the region.

UNEXPOSED ROCK FORMATIONS

Introductory Statement

Because no formations older than the Silurian are exposed in this quadrangle, the interpretation of the history of the area prior to the Silurian period is dependent upon well records and a study of neighboring districts. Plate III is a graphic correlation table of certain deep well logs (see Table 9) for the area near Joliet. These sections show the elevations and depths of the contact surfaces, and also the thicknesses and characteristics of the various formations. Figure 2 is a diagrammatic representation of the columnar section for the area, adapted from the chart of deep wells.

[1] Barrell, Joseph, Measurements of geologic time: Bull. Geol. Soc. Am., vol. 28, p. 752, 1916.

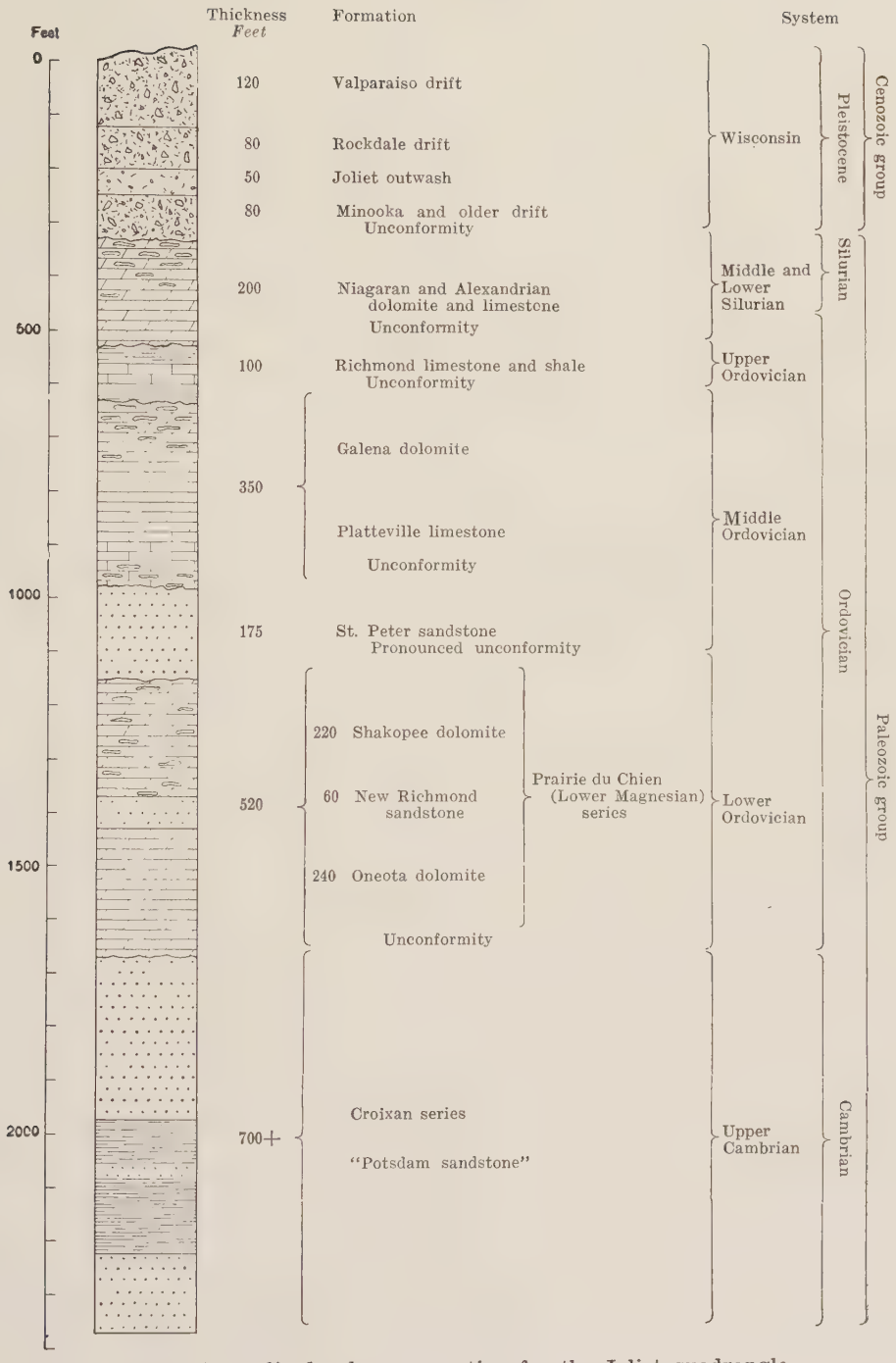

Fig. 2. Generalized columnar section for the Joliet quadrangle.

Cambrian System

The oldest rocks encountered in the wells of the area are sandstones and shales, probably Croixan or upper Cambrian in age (fig. 2). What lies below these beds in this area is unknown, but in Wisconsin, some 150 miles to the northwest where these and older rocks outcrop at the surface, the underlying formations consist mainly of quartzites, very hard rocks composed essentially of quartz. The Croixan formations are very widespread, and were deposited in a sea which covered much of the present area of the United States. At that time most of Canada was land, and the sands and muds which now make up the Croixan rocks of the area were probably largely derived from this great Canadian land mass. The rivers carried the material into the sea where it gradually settled to the bottom, and eventually was cemented into solid rock.

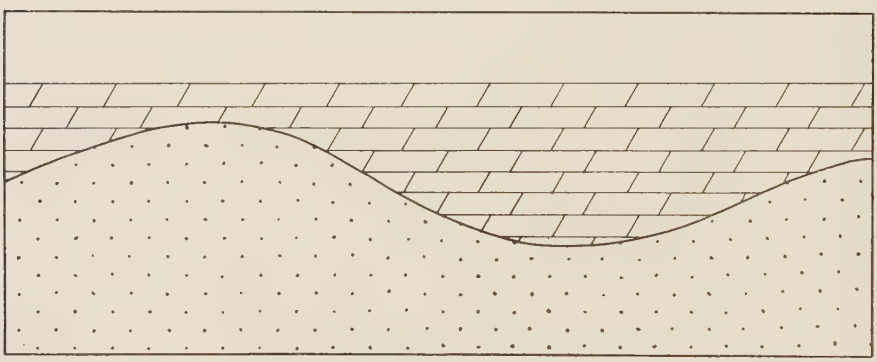

Fig. 3. Diagram to show an erosional unconformity such as exists between the Croixan sandstone and the Oneota dolomite (of early Prairie du Chien age). The lower formation had been eroded before the deposition of the upper.

The Cambrian sea remained in the region for a long period of time, as shown by the fact that the Bensenville well 17 miles northwest of Chicago, penetrates the Croixan formation nearly 1,000 feet without reaching its base. It finally withdrew from the region, perhaps as the result of uplift of the land caused by the action of internal forces, and the newly-made beds were subjected to the erosive action of wind, water, and all the other agencies of weathering and erosion that tend to disrupt solid rock. Later, the sea returned, and another series of sediments was deposited, as shown by the relations between the Cambrian and the overlying strata. The younger formations overlie the Cambrian beds in the manner shown diagrammatically in figure 3. It is evident that the more or less level surface of the Croixan sandstone had been eroded by rivers before the later sedi-

WEST

EAST

Elevation in feet

600
+500
+400
+300
+200
+100
Sea level
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
-1400
-1500

335 340 321 329 301 350 261 304 300 277 337 336 303 319 302 318

No record

Glacial drift — Pleistocene system

Niagaran dolomite and limestone

Kankakee limestone and dolomite

Edgewood limestone and dolomite — Silurian system

Richmond shale

Galena dolomite

Platteville limestone

St. Peter sandstone

Prairie du Chien series — Ordovician system

Croixan series — Cambrian system

LEGEND

Limestone, Dolomite, Shale, Sandstone, Siltstone, Marl, Chert, Cherty, Drift, Broken limestone

229 Lockport City Well
237 Dellwood Park Well
240 New Penitentiary Well No. 2
261 Illinois Steel Mill Well
277 Williamson Avenue Well, Joliet
300 Canal and Division Street Well, Joliet
301 Ruby Street Well, Joliet
302 Crowley Avenue and Ottawa Street, Joliet
303 Sehring Brewing Company Well
304 Van Buren Street Well, Joliet
318 Old Water Works Well, Joliet
319 Spruce Slip Well, Joliet
320 Des Plaines Street Well, Joliet
321 Jasper Street Well, Joliet
335 Rockdale City Well
336 Superior Alum Works Wells

Diagrammatic correlation of the logs of the deep wells of the Rockdale, Joliet, Lockport district, by George E. Ekblaw. For location of wells, see Plate II. For detailed records of wells, see Table 9.

[1] Cady, G. H., Geology of the Hennepin and La Salle quadrangles: Ill. State Geol. Survey Bull. 37, p. 35, 1919.

mentary formations were deposited, as the younger rocks fill the valleys in the Cambrian sandstone.

Ordovician System

GENERAL STATEMENT

The Ordovician period is divided into three epochs: the Lower Ordovician or Prairie du Chien epoch; the Middle Ordovician epoch, during which the St. Peter sandstone and the Galena-Platteville calcareous formation were formed; and the Upper Ordovician epoch, which is represented in this part of Illinois by the Richmond beds only, considered to be of late Upper Ordovician age (fig. 2). The total thickness of the Ordovician system in most parts of this area is between 1,000 and 1,200 feet, although in the Old Water Works Well (No. 318, Pl. III), only 948 feet of Ordovician are penetrated. The maximum thickness is 1,203 feet in the well of the Sehring Brewing Company (No. 303, Pl. III).

LOWER ORDOVICIAN SYSTEM

PRAIRIE DU CHIEN SERIES

D. D. Owen first called this the Lower Magnesian limestone, about 1840, and in 1906 Bain and Grant first used the present designation, the Prairie du Chien series.

Rocks belonging to the Prairie du Chien series do not outcrop within the Joliet area. They can be seen along Illinois River near La Salle, where the section shows only the upper member (the Shakopee dolomite) of this series, which Cady[1] says is the only one appearing at the surface in the whole State. Sand, which later became sandstone, was the dominant deposit in the Cambrian sea, but the first sediment deposited in the Ordovician sea was calcareous, which later became dolomitic. As calcareous sediments indicate relatively clear water, perhaps the neighboring land mass was too low to yield much sand and mud.

As a whole, the well records in the Joliet area show an average of about 520 feet of sediments which may be referred to the Prairie du Chien series. Calcareous material predominates, but shale is more abundant than sandstone. Most wells show that the lowest member of the Prairie du Chien was a calcareous sediment which may be correlated with the Oneota dolomite, although well No. 336 (Table 9 and Pl. III) has shale as the basal member of the series. The New Richmond sandstone, the middle member of the Prairie du Chien series, conformably overlies the Oneota dolomite. It may be represented in wells No. 277, 300, and 304. The Shakopee dolo-

[1] Cady, G. H., Geology of the Hennepin and La Salle quadrangles: Ill. State Geol. Survey Bull. 37, p. 35, 1919.

mite the top member of the Prairie du Chien series, seems to be represented in most of the well records.

MIDDLE ORDOVICIAN SYSTEM

ST. PETER SANDSTONE

General description.—The St. Peter sandstone is not exposed in this area, but outcrops along Illinois River between Ottawa and Utica, north of Utica, and in the lower Fox River valley. It is composed of remarkably uniform and pure, well rounded, white, quartz sand with fossils in but few places. Well records of the area listed in Table 9 or shown on Plate III, show that the thickness of the St. Peter sandstone ranges between 70 and 495 feet, with an average of about 230 feet. It is to be noted that wells No. 277 and 320 show thicknesses of sand of 495 and 450 feet respectively at the St. Peter horizon. These are very great thicknesses for the St. Peter formation, and if the drill samples were correctly determined, can best be explained by the filling of deep valleys in the eroded Prairie du Chien surface (Plate III). One such ancient valley seems to lie directly under the present Des Plaines channel through the center of Joliet.

Culver[2] states that in the Morris area the St. Peter beds dip toward the southeast more than 28 feet per mile. Cady[3] shows the St. Peter sandstone to have a slight dip, about 7 feet per mile, in a southeasterly direction within the Joliet area. In the immediate vicinity of Joliet, the St. Peter strata dip 1¼° (112 feet to the mile) in an easterly direction.

After the more or less continuous sedimentation of the Prairie du Chien epoch, the sea withdrew, and land conditions again obtained within the area, so that the upper beds of the Prairie du Chien series were subjected to erosion. It has been conjectured that essentially desert conditions prevailed, as the sand was conceived to be wind-blown sand comparable to that of some deserts. Recent work, however, reveals that the stratigraphic relations, character of sediments, structure, and fossil content indicate a marine origin for the formation.[4] The St. Peter sea gradually advanced up the Mississippi basin from the south, and in it the St. Peter sands were laid down, or if the sands were there before, the sea reworked them, for they contain marine fossils in various places. Wherever observed, this sandstone shows an erosional unconformity at its base, proving the existence of land conditions after the Prairie du Chien series was deposited, and before the St. Peter sandstone was laid down. Following the

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[2] Culver, Harold E., Geology and mineral resources of the Morris quadrangle: Ill. State Geol. Survey Bull. 43B, p. 75, 1922.

[3] Cady, G. H., The structure of the La Salle anticline: Ill. State Geol. Survey Bull. 36, Pl. II, 1920.

[4] Dake, C. L., The Problem of the St. Peter sandstone: Univ. of Mo. School of Mines and Metallurgy, Vol. 6, No. 1, p. 194, 1921.

withdrawal of the sea, the sandstone was eroded, deeply in some places, before the deposition of the overlying formation.

GALENA-PLATTEVILLE FORMATION

Later, another re-advance of the sea into the Mississippi Basin from the south covered the central states, and the sediments deposited in it buried the St. Peter sandstone. These sediments were mostly calcareous and now constitute the Galena-Platteville dolomite and limestone.

The Galena and Platteville can not easily be differentiated in the well records, and so are commonly grouped together. The Galena is probably equivalent to the "Trenton" limestone, which contains oil in Ohio and Indiana.

The Galena-Platteville outcrops west of the Joliet quadrangle in the area north of Morris, covering most of the western half of Kendall County, as well as a large part of the State to the northwest (fig. 4). The average thickness of the Galena-Platteville formation, as shown by wells in the Joliet quadrangle, is slightly less than 350 feet.

UPPER ORDOVICIAN SYSTEM

RICHMOND FORMATION

Beds of Richmond age (the equivalent of the Maquoketa in the Iowa region) outcrop in a narrow and discontinuous belt extending north and northwest from Paxton, Illinois, into Wisconsin (fig. 4). They were nowhere seen at the surface in the Joliet quadrangle, but Richmond limestone appears about one mile south of the quadrangle in the banks of the DuPage and the bed of Rock Run. It is possible but not probable that Richmond beds form the bed rock in the extreme southwestern corner of the quadrangle, but a heavy covering of glacial drift prevents exposures. Two miles west of this corner, Culver[5] has mapped the Richmond formation in the bed of Aux Sable Creek. He states that the formation is divisible into three members, which is in agreement with Cady's conclusions.[6] These comprise an upper shale some 75 feet in thickness overlying about 50 feet of pure limestone which rests on 60 to 70 feet of shale. The upper member is missing in the Morris area, and the maximum exposed thickness of the formation is only about 20 feet. Only two well records of the Joliet area show two shale horizons which may be correlated as the Richmond. One of these is the New Penitentiary well, No. 239 (Table 9), which shows 80 feet of shale above 100 feet of limestone, with 110 feet of shale below. It is possible that these three are all of Richmond age, although such a

[5] Culver, Harold E., Geology and mineral resources of the Morris quadrangle: Ill. State Geol. Survey Bull. 43B, p. 37, 1922.

[6] Cady G. H., Geology of the Hennepin and LaSalle quadrangles: Ill. State Geol. Survey Bull. 37, p. 46, 1919.

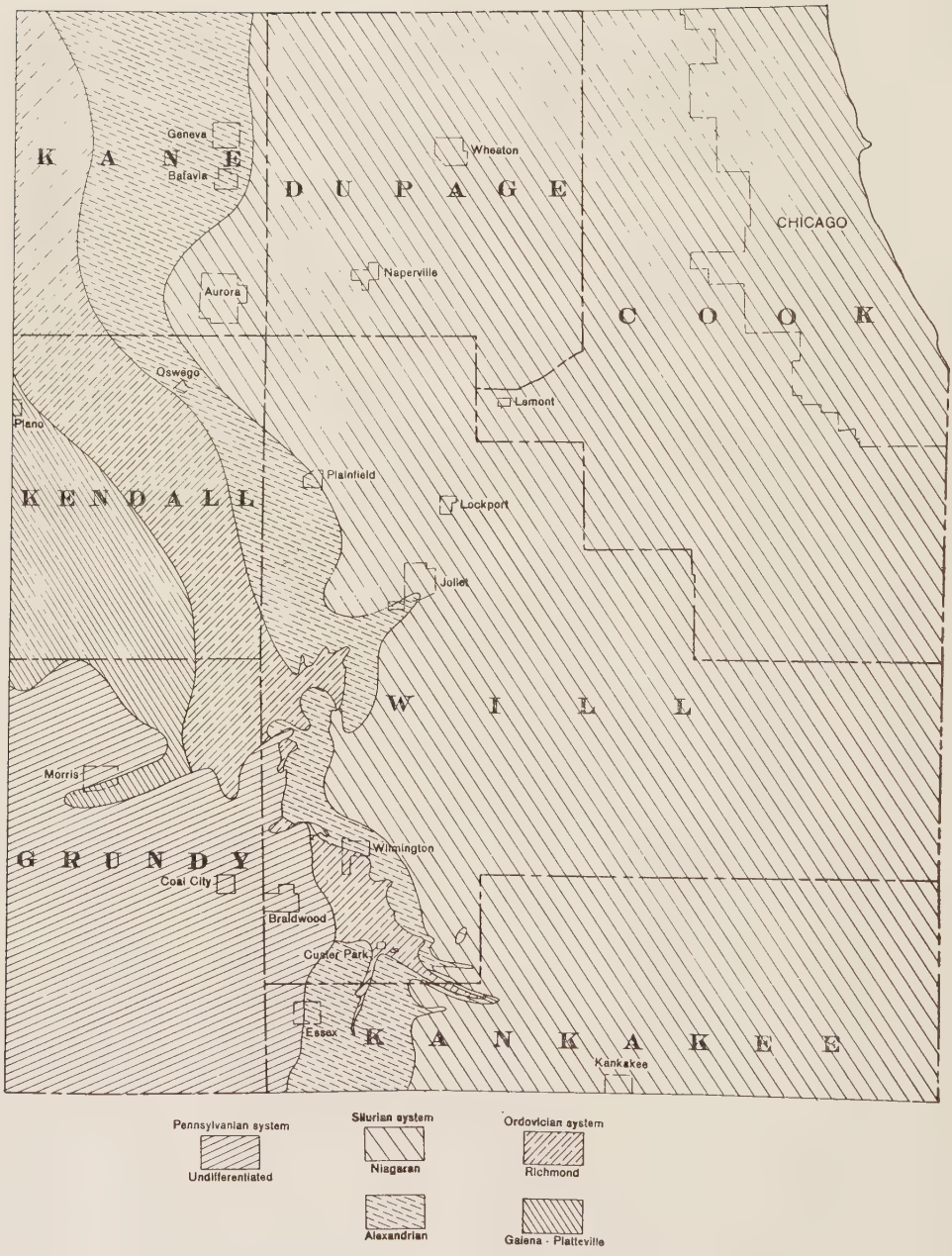


Fig. 4. Geologic setting of the Joliet area. The boundaries in Kane and Kendall counties are approximate. Scale: 1 inch = about 11 miles.

thick section is extremely doubtful. The well at the Superior Alum Works, No. 336 (Table 9) shows 15 feet of shale over 8 feet of limestone, which in turn overlies 135 feet of shale, all of which may be of Richmond age. All the other wells recorded on Plate III show only one shale horizon near the Richmond level, and how much of the overlying or underlying limestone may also be of Richmond age cannot be determined. This shale shows an average thickness of about 100 feet in the Joliet quadrangle well records, but the figures vary from 68 to 140 feet.

There was presumably an interruption in sedimentation between the Galena-Platteville and the Richmond epochs as the lower and middle divisions of the Upper Ordovician series are apparently missing. However, Culver states that in the neighboring Morris area the two formations are not separated by a marked unconformity.[6] The Richmond is separated from the overlying Silurian rocks by an unconformity.[7]

EXPOSED ROCK FORMATIONS

Silurian System

ALEXANDRIAN SERIES

The early Silurian period is represented in Illinois by the Alexandrian series, which has been divided into three formations: (1) the Girardeau, or basal, (2) the Edgewood, or middle, and (3) the Kankakee, or uppermost formation.

The Girardeau is represented by about 35 feet of limestone in southern Illinois and adjacent areas, but is unknown in northeastern Illinois. The Edgewood is composed of calcareous sediments found as far north as Kendall and Will counties. The Kankakee formation consists of limestone (in part dolomitic), and extends as far south and west as Calhoun County. The Edgewood formation was deposited in a sea which advanced from the south. After this sea withdrew, according to Savage[8] a sea advanced from the north and in it the Kankakee sediments were laid down. The evidence for such a succession is based on paleontologic grounds.

EDGEWOOD FORMATION

The Edgewood formation probably reaches a thickness of at least 60 feet in Will County, and includes all Silurian strata below the base of a thin zone carrying abundant specimens of the brachiopod *Platymerella man-*

[6] Culver, Harold E., Geology and mineral resources of the Morris quadrangle: Ill. State Geol. Survey Bull. 43B, p. 37, 1922.

[7] Savage, T. E., Stratigraphy and paleontology of the Alexandrian series in Illinois and Missouri: Ill. State Geol. Survey Bull. 23, p. 94, 1917.

[8] Savage, T. E., Alexandrian rocks of Illinois and Wisconsin: Bull. Geol. Soc. Am., Vol. 27, p. 315, 1916.

EXPLANATION OF PLATE IV

Fig. 1. *Platymerella manniensis*, Foerste. Brachial and lateral views of a slightly elongate specimen. Base of Kankakee formation, 2 miles south of Channahon, Illinois.

Fig. 2. *Stricklandinia pyriformis*, Savage. Brachial and lateral views of an internal cast of a thick, circular individual. Near the top of the Kankakee limestone, north-central part of sec. 22, Troy Twp., in the west bank of Rock Run.

Figs. 3-4. *Stricklandinia pyriformis*, Savage. Normal size shells of different shapes; W. M. No. 12,282; Drummond, Illinois.

Fig. 5. A *Dinorthis* or *Schuchertella;* Weller Coll., Joliet, Ill.

Fig. 6. *Orthis flabellites*, Foerste. Internal cast of the brachial valve; Weller Coll., Joliet, Illinois.

Fig. 7. *Dalmanella elegantula*, Dalman. Internal cast of the brachial valve; pedicle valve is strongly convex; Weller Coll., Joliet, Illinois.

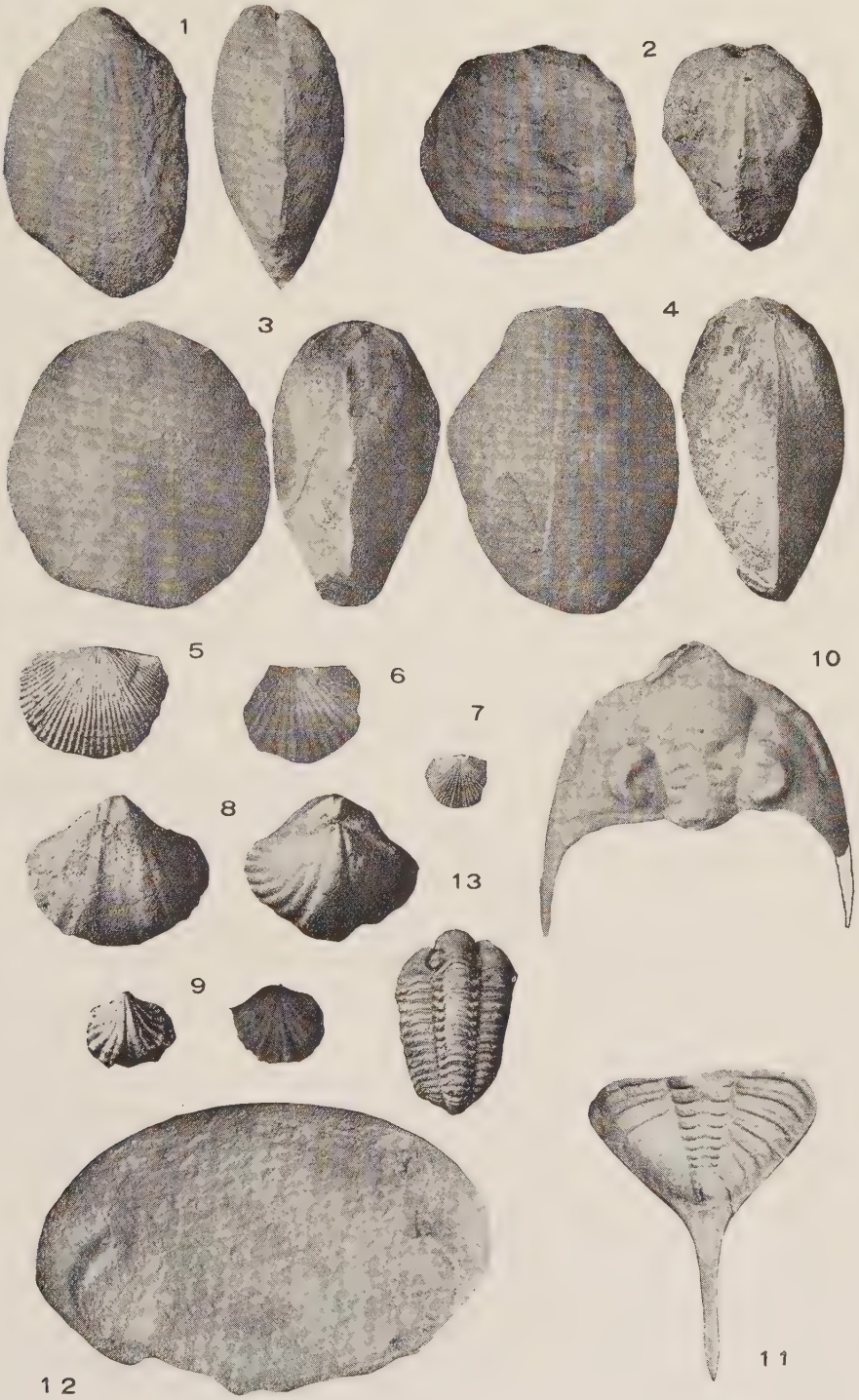
Fig. 8. *Spirifer eudora*, Hall. Internal casts of the pedicle and brachial valves; Van Horne Coll., Joliet, Illinois.

Fig. 9. *Atrypa marginalis*, Dalman. Pedicle and brachial views; Weller Coll., Joliet, Illinois.

Figs. 10 and 11. *Dalmanites platycaudatus*, Weller. Dorsal view of a plaster cast made from a natural mold of the head (cephalon), and dorsal view of an internal cast of the tail (pygidium) of another individual; W. M. Nos. 10,752 and 9878; near Lemont, Illinois.

Fig. 12. *Bumastus graftonensis*, Meek and Worthen. Dorsal view of an internal cast of the head (cephalon); W. M. No. 18,111; Lemont, Illinois.

Fig. 13. *Calymene celebra (niagarensis)*, Raymond. Dorsal view of an internal cast of a nearly complete individual. This is by far the most common trilobite in the area; W. M. No. 22,017; Joliet, Illinois.



Fossils from the Niagaran and Alexandrian strata.
1-9, brachiopods; 10-13, trilobites. All natural size. All specimens but 1 and 2 from Walker Museum. 1-4, Alexandrian; 5-13, Niagaran.

niensis (Pl. IV). Wherever the contact between the Edgewood and Kankakee is exposed along DuPage River (Pl. I), this *Platymerella* zone can be observed. In many exposures it is made up of a layer of chert 4 inches or less in thickness. This zone was not seen on Rock Run. The Edgewood formation is composed largely of dolomite, but contains some limestone and some chert.

The best exposure of Edgewood strata in the Joliet quadrangle may be seen along DuPage River west of Center School, sec. 21, T. 35 N., R. 9 E., on the east bank just north of the bridge, where some six feet of Edgewood strata are exposed. The upper five feet consist of a dense, white dolomite which weathers to a pale buff color. It is medium-bedded with beds up to

Fig. 5. Kankakee-Edgewood contact, east side of DuPage River, section 16 Troy Township (T. 35 N., R. 9 E.). The thick, prominent layer is just above the *Platymerella* zone.

6 inches thick and contains a few chert layers, much of which is banded. It has a gentle dip upstream, and some 200 yards above the bridge the *Platymerella* zone appears only slightly above the water level, overlain by 4 to 5 feet of heavy-bedded, dense gray to somewhat "vesicular" brownish limestone of Kankakee age (fig. 5).

At the base of the Edgewood section near the bridge appears one foot of a hard, dense, gray dolomite which weathers to a bluish to buff platy rock. This is somewhat thicker on the west bank below the bridge, and half a mile south of the Joliet quadrangle, in the west bank of DuPage River appears a 20-foot section of this dolomite. Fossils are especially

abundant here in a horizon about 12 feet above the water. The fauna consists mainly of brachiopods and trilobites, the brachiopods largely predominating. Among the brachiopods are:

Atrypa praemarginalis
Orthis flabellites
[a]Dalmanella cf. edgewoodensis
[a]Platystrophia daytonensis

[a] Determination by Professor Savage.

The only trilobite sufficiently well preserved for identification was an apparently new species of *Calymene*. Several fragments of trilobites (mainly tails) could not be determined.

Near the south edge of the quadrangle, in the west bank of Du Page River, the Kankakee limestone appears, due to the presence of a structural basin or an eastward plunging syncline which carries the Edgewood strata below water level. The contact with the *Platymerella* zone may be well seen at the mouth of the gully in the NW. ¼ of sec. 21, T. 35 N., R. 9 E. Upper Edgewood strata are also exposed along Rock Run in section 22 of the same township (Pl. I).

In T. 35 N., R. 9 E., Edgewood rocks are also exposed underlying Kankakee beds in the central part of sec. 16 along the west bank of Du Page River and in the east bank at the bridge near Grinton, SW. ¼ sec. 10 (Pl. I). In both cases these exposures are the result of gentle upbowings of the strata, and only a few feet of Edgewood rocks are exposed. The strata along Rock Run have a dip of about one degree to the north; thus along Rock Run one mile south of the Joliet quadrangle a lower nonfossiliferous horizon of the Edgewood is seen. In this exposure the rock weathers into buff-brown, thin, sandy-appearing layers. The underlying Richmond limestone is here exposed in the bed of Rock Run.

KANKAKEE FORMATION

The Kankakee formation includes all rocks lying above the base of the *Platymerella manniensis* zone and below the Niagaran dolomite. In the Joliet area, the Kankakee consists of at least 20 feet of medium to heavy bedded rock which varies from a brownish "vesicular" to a dense gray limestone, in places dolomitic. Along the southeast bank of DesPlaines River two miles southwest of Joliet the Kankakee formation is considered to be approximately 70 feet thick. From one to seventeen feet below the top of the Kankakee formation is found a discontinuous layer 2 to 4 inches thick containing casts of the brachiopod *Stricklandinia pyriformis* (Pl. IV-2-4). Savage[8] states that farther to the south the *Stricklandinia* zone is

[8] Savage, T. E., Alexandrian rocks of Illinois and Wisconsin: Bull. Geol. Soc. Am., Vol. 27, p. 312, 1916.

found near the middle of the Kankakee formation from 18 to 25 feet above its base.

Good exposures of Kankakee rocks in the Joliet area may be seen in the banks of both branches of Rock Run in section 22, T. 35 N., R. 9 E., and slightly north of this place in section 15. A good exposure (fig. 6) is shown in the east side of the valley wall, at the center of the east side of the NE. ¼ of section 22 (Pl. I). At this point a 3 to 4-foot section of buffish to pinkish, dolomitic limestone in 3 to 4-inch beds is exposed, overlain by some 4 feet of very thin-bedded, white, compact dolomite. The upper beds appear to be typical Niagaran dolomite. Both sets of beds show

Fig. 6. Kankakee-Niagaran contact indicated by the head of the upper hammer. The head of the lower hammer is at the *Stricklandinia* horizon. East bank of the East Branch of Rock Run, section 22, Troy Township (T. 35 N., R. 9 E.).

a dip of about 3°, N. 85° E., and the contact, which is quite sharp, appears conformable. Near the middle of the lower set of beds, which is of Kankakee age, there is a highly fossiliferous layer about 3 inches thick. This layer is made up chiefly of imperfect specimens of *Stricklandinias,* although there are also a number of poorly preserved cup corals, *Zaphrentis cf. stokesi.* Dolomite and limestone outcrop almost continuously for a mile along this valley north and south of this locality, but fossils are hard to find in it.

In the south-central part of section 15, T. 35 N., R. 9 E., in the east bank of the main branch of Rock Run, Kankakee strata are well exposed (fig. 7). Here the following section was measured:

Section of strata exposed in sec. 15, T. 35 N., R. 9 E.

		Thickness	
		Ft.	*In.*
3.	Dolomite, buff, weathering into lighter-colored layers an inch or less in thickness	5	..
2.	Limestone, heavy-bedded, brownish containing the *Stricklandinia* zone one foot below its top and with numerous fragmentary fossils above the *Stricklandinias*	3	2
1.	Limestone, dense white, weathering into layers an inch or less in thickness	1	..

No. 3 of the above section is considered to be of Niagaran age, as it is similar to the Niagaran lithologically. No good fossils were found in it. Nos. 1 and 2 belong to the Kankakee. In the west bank of Rock Run, 300

Fig. 7. Kankakee-Niagaran contact indicated by the head of the pick (upper). The head of the small hammer (lower) is at the *Stricklandinia* horizon. East bank of Rock Run, section 15, Troy Township (T. 35 N., R. 9 E.).

yards south of the above section, excellent samples of *Stricklandinias* were found about 12 feet higher than those in No. 2 above. Large slabs composed of an almost solid mass of these shells (fig. 8) were removed here.

The strata in the east bank of Du Page River near Grinton, section 10, T. 35 N., R. 9 E., are considered to be of Kankakee age, with the exception of the Edgewood formation, before noted (Pl. I). An indistinct *Stricklandinia* horizon was observed 100 yards above the bridge and 5 feet above water-level. There is 3 feet or more of limestone lying above the *Stricklandinias* here, all of which is grouped with the Kankakee.

The age of the limestone exposed at intervals along Du Page River north of Grinton, section 10, T. 35 N., R. 9 E., to Plainfield, section 16, T.

36 N., R. 9 E., is not definitely known, as no diagnostic fossils could be secured from it. It is, however, mainly on the basis of lithology classed with the Kankakee. It is somewhat similar to the rock found about 8 miles south of Grinton near Drummond, section 27, T. 34 N., R. 9 E., (Wilming-

Fig. 8. Slab of Kankakee limestone showing numerous casts of the brachiopod *Stricklandinia pyriformis*, Savage. From the west bank of Rock Run in the north-central part of section 22, Troy Township (T. 35 N., R. 9 E.). (x approximately ⅓.)

ton quadrangle), which is considered to form the upper part of the Kankakee. Moreover, the outcrop near Plainfield in sec. 16, T. 36 N., R. 9 E. (Pl. I) contained several large trilobite tails, belonging to the genus *Illaenus* (quite

resembling, the *Bumastus* shown in Pl. IV-12), generally found near the top of the rock at Drummond. In section 3, Troy Twp., (T. 35 N., R. 9 E.) on the west bank of Du Page River, a 10-foot bluff of this rock may be seen. It weathers into layers an inch or so in thickness, and in large part is made up of a very dense, fine, hard limestone containing very little chert. The color is light gray with a tendency towards a pinkish cast.

An excellent section is exposed in the quarry of the Markgraf Stone Company in the SW. ¼ of sec. 16, Joliet Twp. (T. 35 N., R. 10 E.) barely within the city limits. Two feet above the base of the quarry the *Stricklandinia pyriformis* zone appears. One foot above this zone there is a peculiar bedding surface characterized by its smooth appearance, which is essentially plane, except for numerous small pits about ¼ of an inch in diameter and up to ½ an inch deep. These pits appear to be due to the weathering out of roughly cylindrical masses of medium gray shaly limestone that may be the petrified remains of stems or roots of plants (fucoids). Associated with this smooth surface are iron disulphide (pyrite) and a powdery greenish mineral that may be glauconite (a hydrous potassium iron aluminum silicate). Other bedding planes in this rock are not smooth, but are rough and hummocky.

This smooth surface is found about one foot above the *Stricklandinia* zone at many places between Joliet and Essex (fig. 4) and is possibly the result of a "halting condition," or an interval of time when neither deposition nor erosion was an active process. If this is true, it may mark the contact between the Kankakee and Niagaran strata. This surface is actually thought to mark the contact in the sections previously described in the NE. ¼ of sec. 22 and in the south-central part of sec. 15, Troy Twp. (T. 35 N., R. 9 E.)

Elsewhere, as along Prairie Creek and Kankakee River near their junction some four miles below Wilmington, it is thought that the actual contact lies a few feet above the smooth surface, since here this surface marks no lithologic change, but, on the contrary, a few feet of strata above the surface are of the characteristic Drummond type of Kankakee limestone.

A similar situation is presented in the Markgraf quarry where the lithologic break between typical Kankakee and Niagaran rocks is 16 feet above the smooth surface. This 16 feet of strata consists of a light gray to pinkish, non-cherty, non-fossiliferous rock with thin, shaly-appearing partings. In the quarry it is broken out into blocks 6 to 16 inches thick, made up of many layers ½ to 1 inch thick separated by thin greenish-gray partings which cause the rock to appear very thin-bedded on a normal weathered surface. These strata appear lithologically like the strata immediately below the smooth surface, and therefore are considered to be of

Kankakee age. At the top of the 16-foot stratum is a 4-inch bed of medium gray, shaly-appearing, dense limestone which weathers light gray and appears irregularly laminated. This bed is considered to mark the Kankakee-Niagaran contact, and presumably represents Kankakee sediments reworked by the advancing Niagaran sea. It is also well exposed 8 to 9 feet above the base of the quarry of the National Stone Company in the SE. ¼ of section 21, Joliet Twp. (T. 35 N., R. 10 E.). Above this bed appears typical massive, heavy-bedded, light gray Niagaran dolomite carrying chert.

Drawing the Kankakee-Niagaran contact at some places along the smooth surface, and at other places a few feet above this surface, is consistent with the known unconformity that separates the Kankakee and Niagaran strata. This unconformity is very obviously present near Millsdale, seven miles southwest of Joliet. Moreover, unless some lithologic types are considered to be characteristic of the one or the other horizon, the mapping of isolated non-fossiliferous exposures could not be satisfactorily accomplished.

Summarizing, it is seen that the exposed consolidated rocks of the area are all carbonates, and there is no marked lithologic differences between certain phases of the various horizons. On the other hand, there are particular types of rock that are distinct lithologically and so serve to distinguish a given horizon. In this area the dividing surface between the Edgewood and Kankakee strata is perhaps somewhat arbitrarily set at the base of the *Platymerella* zone, since elsewhere[9] this horizon is marked by an unconformity. There is now recognized in the area no such fossil zone separating the Kankakee from the Niagaran. The two may be separated on a lithologic basis, or along the smooth surface, or locally both criteria may be used, but, in any case, the smooth surface lies near the top of the Kankakee. The contact is here drawn mainly on a lithologic basis. Along Rock Run this coincides with the smooth surface; near Joliet it lies 16 feet above this surface. At other localities on the Wilmington quadrangle south of Joliet it is thought to lie between these two limits.

NIAGARAN DOLOMITE

With the exception of the Alexandrian rocks above noted, the bed rock of the Joliet area so far as observed consists exclusively of Niagaran dolomite. Sometime after the withdrawal of the late Alexandrian sea, another sea in which the Niagaran dolomite was deposited advanced southward from the Hudson Bay region and eventually covered a large part of North America. Over wide areas a relatively pure dolomite was formed, showing that the sea was fairly clear. This dolomite is the bed rock over almost the whole northeastern corner of Illinois (fig. 4).

[9] Savage, T. E., Idem, p. 314.

DISTRIBUTION

The map (Pl. I) shows the widespread occurrence of exposures of Niagaran dolomite. In all cases the outcrops are in or near valleys, although their elevations vary from less than 520 feet to more than 670 feet above sea level. The whole floor of Des Plaines Valley from Lemont to Joliet is made up of the formation, but locally it is buried by a few feet of later deposits. Isolated outcrops are mapped in Du Page Valley, although no exposures were seen along East Branch. Twelve outcrops are shown in the various tributary valleys, not sufficiently important to deserve specific mention.

GENERAL DESCRIPTION

Constitution.—In most places the upper part of the Niagaran formation consists of a thin-bedded, highly-weathered, cherty dolomite of a buff-yellow color, commonly called limestone. The chert, a very compact, fine-grained material composed largely of silica and harder than a knife blade, is either in beds about two inches thick or in ellipsoidal nodules, commonly about the size of a goose egg, that are generally in layers parallel to the bedding, but in some cases are sporadically distributed. Below these chert-rich layers the rock is more heavily bedded, with beds commonly 6 to 36 inches thick, compact, even-textured, sub-crystalline, bluish-gray on a fresh surface, and contains a much smaller proportion of chert. Occasionally small cavities, commonly less than ½ an inch in diameter, are seen, some of them containing numerous minute quartz or calcite crystals. Abundant chert is not everywhere found at the top of the Niagaran formation, however, for in the bluff along the east side of Des Plaines Valley near Fraction Run, T. 36 N., R. 10 E., about 6 feet of very thin-bedded, extremely cherty dolomite is overlain by several feet of medium to thin-bedded, nearly chert-free dolomite.

The chemical composition of the rock is given in the table below.

TABLE 2.—*Analyses of Niagaran dolomite*[10]

	(1) (Romeo)	(2) (Romeo)	(3) (Joliet)
SiO_2	1.99	1.90	1.40
Al_2O_3	.63	.64	.12
Fe_2O_3	1.15	2.08	.78
$CaCO_3$	53.73	52.61	54.67
$MgCO_3$	42.13	41.84	42.90
Totals	99.63	99.07	99.87

Nos. 1 and 2 are average analyses from the quarry of the Joliet Flux Stone Company at Romeo. Minor amounts of sulphur and phosphorus are also

[10] Burchard, E. F., Concrete Materials Produced in the Chicago District: Ill. State Geol. Survey Bull. 8, p. 355, 1907.

present. No. 3 was furnished at the plant office of the National Stone Company, Joliet.

The writer is greatly indebted to D. F. Higgins of the University of Chicago for the following detailed chemical analysis made from a sample of dense, massive, faintly greenish-gray Niagaran dolomite taken from near the bottom of the quarry of the National Stone Company, Joliet.

	Per cent
SiO_2	7.96
Al_2O_3	1.97
Fe_2O_3	0.14
FeO	0.56
CaO	26.72
MgO	19.46
Na_2O	0.42
K_2O	0.16
H_2O	0.33
H_2O-	0.30
CO_2	41.13
TiO_2	0.12
ZrO_2	Trace
P_2O_5	0.91
S	0.19
Cr_2O_3	None
MnO	0.07
BaO	None
Total	100.44

This corresponds to 40.68 per cent $MgCO_3$ and 44.23 per cent $CaCO_3$, which uses up all of the CO_2 present, leaving 1.95 per cent CaO not combined as the carbonate. The hand specimen showed speckled masses of pyrite, which were excluded from the material analyzed. The small amount of iron and the relatively large figures for SiO_2, Al_2O_3, and P_2O_5 are worthy of notice. It has become the custom to call limestones containing from 18 to 40 per cent of magnesium carbonate, "dolomites". The true mineral, dolomite, is composed of 54.35 per cent calcium carbonate and 45.65 per cent magnesium carbonate, but with present usage of the term it will be seen from the results of the analyses (Table 2) that the Niagaran should be called a dolomite.

Thickness.—The original thickness of the dolomite in the area is unknown, since erosion has undoubtedly removed much from the top of the formation. The deep wells of the Joliet quadrangle (Table 9) penetrate an average thickness of some 200 feet of dolomite and limestone before entering the Richmond shale. The minimum thickness obtained in a reliable well log is 140 feet (well No. 319), and the maximum 312 feet (well No. 318).

Probably at least 100 feet of this belongs with the Alexandrian. Some artesian wells in Chicago go through 400 feet of the dolomite. Obviously since the Silurian is made up of nearly horizontal strata, and since its surface is quite uneven (it has a relief of more than 170 feet within the quadrangle), its thickness depends in part on the topographic position of its surface. The base of the dolomite is at very few places in the Joliet area lower than 300 feet above sea-level, and with the aid of the bed rock surface contour map (Pl. II), a maximum thickness can easily be computed within a reasonable limit of error for any point in question.

STRUCTURE

Attitude of the beds.—The beds of the Niagaran dolomite do not everywhere maintain their nearly horizontal attitude. The terms "dip" and "strike" are used to show the attitude of the beds. The dip is read on a bedding plane in degrees from the horizontal, and is always taken in that direction in which a maximum reading is observed. The strike is a direction obtained by getting the line of intersection of the bedding plane with an imaginary horizontal plane, and is always at right angles to the direction of maximum dip. It is the direction of outcrop on a horizontal surface.

The angles of dip (deviation from the horizontal) of the rocks of the Joliet quadrangle are rarely greater than 5°, although in the east bank of Du Page River, some 300 yards northeast of the bridge on the southern edge of section 16, Troy Twp., (T. 35 N., R. 9 E.) the Alexandrian beds show dips of from 19° to 21° in a general westerly direction. In the bed of Fraction Run in the north part of section 36, Lockport Twp. (T. 36 N., R. 10 E.), measurements on the rough, eroded dolomite surfaces gave readings of dips as high as 17°, in a direction S. 25° E. Farther down the valley, about 150 yards north of the road, dips as high as 7°, N. 40° W. were observed. Local dips of 9 to 10° were read farther downstream in the walls of Fraction Run, and on the southeast side of the valley in the SE. ¼ of the NE. ¼ of section 22, Troy Twp., (T. 35 N., R. 9 E.,) but in both of these places the strata are undulating, and the dips persist for very short distances only. At points on the west side of Du Page River in sections 10 and 21, Troy Twp., (T. 35 N., R. 9 E.,) Plate I shows dips of 10 to 11°, but these also are limited to very small areas. At no localities other than those listed above were dips greater than 5° observed, although many dips less than 5° are recorded on the map.

On the whole, no broad generalization can be made about the attitude of the beds of the Niagaran dolomite based on dip and strike readings. In many places the strata are undulatory, the dips being persistent in one direction for a few rods only. In many cases a slight dip in one direction is, at no great distance, balanced by a correspondingly slight dip in the opposite

direction. These complementary dips may be due to underlying coral reef structure, but there is no other evidence of coral reefs in the formation within the quadrangle, although in some other areas coral reefs are abundant in the Niagaran formation. It seems most logical to explain these complementary dips as being due largely to horizontal stresses acting on brittle dolomite under but a slight cover of later rocks. Brittle rock under slight downward pressure, if subjected to horizontal stresses would tend to bow up with much fracturing, as shown in figure 9, where apparently the dynamiting of a telephone post hole caused this type of action. Similarly it is

Fig. 9. Jointing in the Niagaran dolomite 2 miles south of Joliet along the Chicago and Alton Railway tracks.

Fig. 10. Diagrammatic east-west cross-section of the strata of northeastern Illinois (drawn through Romeo). Vertical scale greatly exaggerated. Horizontal scale, 1 inch equals approximately 10 miles.

believed that horizontal forces, perhaps the same ones that caused the formation of the La Salle anticline, produced on a larger scale this complementary dip structure seen so often within the area. If this hypothesis is correct, dips measured at the surface probably do not hold for any great depth, and little can be told of the structure of the underlying strata of this area from the dips of the surface beds.

On the whole, it is probable that the strata have a very slight easterly dip, since underlying, older rocks outcrop at the surface to the west. The principle on which this deduction is based is illustrated in figure 10. Since

the top of the Niagaran formation is not present, having been removed by erosion, and as there is no "key" bed which can be recognized at different localities and its elevation observed, it is impossible to determine accurately the general dip of the formation from data gathered within the quadrangle limits.

Joints.—Joints, or more or less plane surfaces along which the dolomite is broken, are common in the Niagaran formation. They are generally in two sets, each set containing numerous roughly parallel joints, nearly at right angles to each other and almost vertical. Combined with the horizontal bedding, they cause the rock to break up into angular blocks such as are shown in figure 9. They are of great aid in quarrying, and in the old abandoned quarries around Joliet, many iron-stained vertical faces 10 feet or more in height can be seen, each of which marks the position of a joint plane.

Joints are formed in rock after it has become indurated and are caused by pressure, or relief of pressure, tension, incident to the action of the forces which caused the gentle folding of the beds. The two sets of joints run in general northeast-southwest and northwest-southeast directions, but there are variations from these general directions. The table below gives readings taken in different parts of the quadrangle. The better defined joints are in the northwest-southeast direction.

TABLE 3.—*Direction of joints in the Niagaran dolomite*

Location			Bearing	Dip
Twp.	Sec.	Location in sec.		
Joliet, T. 35 N., R. 10 E.	3	Penitentiary quarry.	N. 35-37° W.	Vertical
			N. 60° E.	Vertical
Joliet, T. 35 N., R. 10 E.	9	NE. ¼	N. 40-41° W.	Vertical
			N. 49-50° E.	Vertical
Joliet, T. 35 N., R. 10 E.	15	SE. ¼	N. 39° W.	Vertical
			N. 52° E.	Vertical
Joliet, T. 35 N., R. 10 E.	21	National Stone Co.	N. 35° W.	Vertical
			N. 55° E.	Vertical
Lockport, T. 36 N., R. 10 E.	33	Commercial Stone Co.	N. 41-45° W.	Vertical
Lockport, T. 36 N., R. 10 E.	34	Southern part	N. 40-42° W.	Vertical
			N. 50-60° E.	Vertical
Wheatland, T. 37 N., R. 9 E.	14	NE. ¼	N. 65° W.	Vertical
			N. 18° E.	Vertical
Plainfield, T. 36 N., R. 9 E.	2	SE. ¼	N. 55° E.	Vertical
			N. 35° W.	83° to SW.
Troy, T. 34 N., R. 9 E.	14	SW. ¼	N. 50° W.	Vertical
			N. 40° E.	Vertical

Faults.—Faults are dislocations of rock strata and are the chief cause of earthquakes. There are probably many minor faults in the Silurian formations, but no large ones were observed. On account of the lack of distinction between the different beds in this formation, faults are not easily recognized. Figure 11 shows a small fault in a 10-foot section of Kankakee limestone just south of Rockdale in the east-central part of section 19 (Pl. I). The fault plane or the surface along which the movement took place, marked by an arrow in the photograph, is nearly vertical, and strikes N. 35° W., that is, in a direction approximately parallel to the better joint system. The heads of the two hammers are on the same bed, but on opposite sides of the fault plane, showing a vertical movement of about 8 inches.

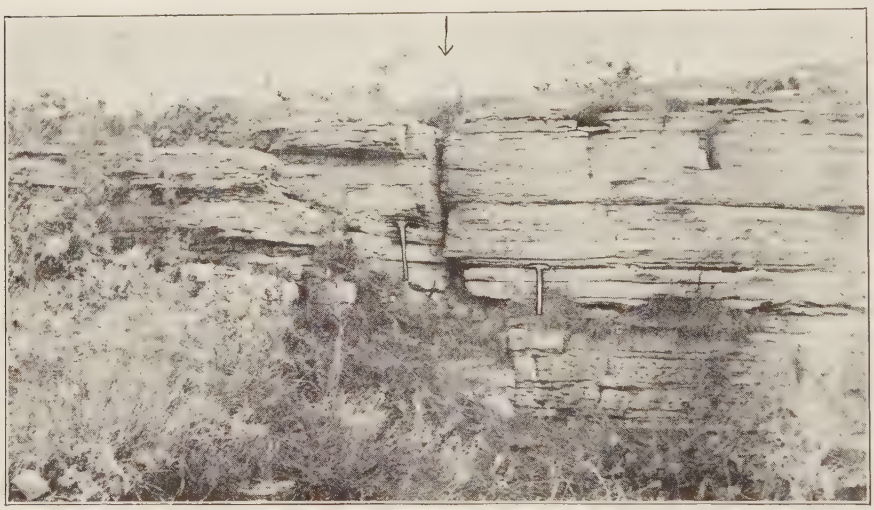


Fig. 11. Faulting in the Kankakee limestone one-fourth mile south of Rockdale (sec. 19, T. 35 N., R. 10 E.).

Two faults with more than a 2-foot displacement and several minor faults were noticed in an abandoned quarry between the main Lockport-Joliet concrete road and the Chicago and Alton tracks about a third of a mile north of Fraction Run. In almost any quarry, minor dislocations of an inch or two can be seen along some joint planes. There has also been some horizontal movement, probably parallel to the bedding planes. Bannister[11] states that "pot holes," or large cavities up to 10 feet in width in the bed of Des Plaines Valley near Lemont which were cut through when the Chicago Drainage Canal was excavated, are occasionally found to be dis-

[11] Cited by Alden, W. C., U. S. Geol. Survey Geol. Atlas, Chicago folio (No. 81, p. 3, 1901.

located along bedding planes, so that in some cases the upper and the lower portions of a "pot hole" are entirely separated from each other.

Goldthwait[12] has described and pictured a small fault with a 1-foot displacement along a vertical fault plane trending in a northwest-southeast direction in the south wall of the gorge of Sugar Run between the two branches of the Chicago and Alton Railroad. He also includes a detailed contour map of Sugar Run gorge, which shows excellent joint planes.

Stylolites.—Stylolites are fluted columns, generally found in calcareous sediments and perpendicular to the bedding planes, which project alternately at right angles from the upper and the lower layers and which interlock in an intricate fashion. They are fairly common in the Niagaran dolomite, and may be seen best in quarries. Fair examples were noted in the quarry of the Commercial Stone Company on the northwest side of Joliet, NE. ¼ section 33, Lockport Twp. (T. 36 N., R. 10 E.). They probably owe their origin to the dissolving action of solutions following bedding planes. The rate of solution would vary at different places, owing to variations in the solubility of the material and to the fact that all grains are not subject to equal pressures at all points. Solution would tend to proceed most rapidly at the points of contact between grains. Differential solution followed by slight displacement thus accounts for stylolites.

Present movements.—That the Niagaran dolomite is actually being deformed at the present time on a very small scale, is attested to by the presence of small ridges or bulges in the floors of many quarries. These are due to expansion of the rock which takes place when a considerable amount of overlying material is removed, or when heated by a summer sun. A low ridge of this type 1-2 feet high and 4-10 feet wide extends with a northeast-southwest trend for some distance along the floor of the State Penitentiary quarry in section 3, Joliet Twp. (T. 35 N., R. 10 E.). This phenomenon can also be observed at many other quarries.[13]

STRATIGRAPHIC RELATIONS

The contact between the Alexandrian, Kankakee, and the Niagaran rocks is well exposed along both branches of Rock Run (Pl. I), and there appears to be conformable (fig. 6). Elsewhere as already noted there is evidence which proves that an erosion interval separated the Kankakee and Niagaran sub-epochs. Savage[14] states that there was a break in sedimentation between the Alexandrian and the Niagaran epochs. No bed

[12] Goldthwait, J. W., Physical features of the Des Plaines Valley: Ill. State Geol. Survey Bull. 11, p. 21 and Plates 2B and 6, 1909.

[13] Idem, p. 20, 1909. Similar warpings are mentioned in the quarry near Crystal Run, northern part of section 33, Lockport Twp. (T. 36 N., R. 10 E.).

[14] Savage, T. E., Stratigraphy and paleontology of the Alexandrian series in Illinois and Missouri: Ill. State Geol. Survey Bull. 23, p. 93, 1917.

rock younger than Niagaran dolomite is known within the area, but it is almost certain that later rocks once covered the quadrangle, and these are thought to have rested unconformably on the Niagaran dolomite.

PRESENT SURFACE CONFIGURATION

The present surface of the Silurian rocks, as it would appear if all later deposits were stripped off, is shown by contour lines on Plate II. This was compiled from a study of the well records in conjunction with the known rock outcrops. Although drawn to a 10-foot contour interval, it is accurate only in a general way, as numerous minor depressions are no doubt present that are not shown on the map. Besides being of value in that it indicates the approximate depth to rock at any given point, it is also useful in interpreting the glacial history of the region, and will be discussed further in that connection.

ORIGIN

As already stated, the Niagaran formation in this area is essentially dolomite. All available analyses of the rock in the whole Chicago district show that it contains more than 40 per cent of magnesium carbonate, except where analyses of the cherty variety were taken, in which case the percentage of silica is high.

While various theories attempt to account for the formation of dolomite, that of marine replacement explains most adequately the Niagaran formation in this area. This postulates that the rock material was deposited on the sea bottom as calcium carbonate, perhaps with a slight magnesium content due to the action of organisms. It was composed chiefly of the calcareous secretions of marine animals which were in some cases ground up into a calcareous mud by the action of waves. The local abundance and widespread occurrence of fossil remains in the formation is convincing evidence of its organic origin. While this limestone was accumulating on the sea bottom, it was continually undergoing dolomization by the gradual replacement of a part of the calcium content of the limestone by magnesium. The widespread extent of the Niagaran dolomite would require a great amount of magnesium, the only known possible source of which was the sea water itself. A long interval of time was required to accomplish dolomization of such an extensive formation, as the reaction must have been carried forward very slowly. The relatively uniform character of the dolomite over a broad area requires a widely and uniformly acting agent for dolomization such as is the sea.

Almost everywhere in the Joliet area, the Niagaran formation contains chert. Chert is finely crystalline silica, silicon dioxide, but differs from sandstone and other siliceous sedimentary rocks in that it is not made up of fragments. It occurs commonly in three ways: (1) as isolated nodules varying from nearly spherical to ellipsoidal to quite irregular shapes, but

with their long axes always parallel to the bedding planes; (2) as layers of such nodules; or (3) as thin sheets, rarely more than 2 or 3 inches thick. The sheets and layers of nodules of chert are separated by varying amounts of dolomite, but commonly are in groups of three, separated by a foot or so of dolomite. Although these sheets or layers of nodules seem fairly continuous in any one exposure, it is generally impossible to find the same sequence in a neighboring exposure, even if the two are at the same elevation.

As is true of dolomite, it is necessary to point out that all chert does not have the same origin. However, certain theories account for the origin of the chert in the Niagaran formation much more satisfactorily than others. That the bulk of the chert found in this dolomite was formed by direct chemical precipitation from the sea water, as perhaps was part of the dolomite, is hardly to be doubted. The widespread distribution of chert in layers of nodules or solid sheets along bedding planes in the dolomite is perhaps the strongest argument in favor of this conception. The sea was apparently the only adequate source of the silica required. Rivers carry both magnesium salts and silica, which have been dissolved from the minerals of the land, to the ocean. Silica in river waters is largely in the colloidal state, a physical condition where the individual particles are very small, but not actually in true solution, as is common salt, for example. Colloidal silica, by the action of certain alkaline salts in the ocean, such as common salt, is coagulated into globules which settle, and so form chert beds in the dolomite. After a certain amount of silica was deposited in this fashion, the amount in the sea water would be decreased, and no more would be thrown down until further additions were contributed by rivers. In the meantime, formation of the dolomite would continue, thus producing the present condition of layers of chert separated by varying thicknesses of dolomite.

However, it must be pointed out that the presence of minute spicular structures of sponges in the chert, seen by G. F. Harris,[15] shows that the formation of the chert was in part at least aided by organisms. Most of the chert shows no sponge structure and the sponge spicules that are found may have served as nuclei about which colloidal silica coagulated.

It has been noted that the upper few feet of the Niagaran dolomite is in many places much richer in chert than other parts of the formation. It seems that this can best be explained by the action of weathering, since very different layers are at the surface in different parts of the region. When the original surface of the Niagaran formation was first exposed to erosion, solution was no doubt effective, and a great deal of the dolomite was removed by ground waters containing carbon dioxide in solu-

[15] Chamberlin and Salisbury, Geology, Vol. II, p. 384.

EXPLANATION OF PLATE V

Fig. 1. *Calathium* sp. W. M. No. 4,666; Joliet, Illinois.

Fig. 2. *Favosites niagarensis*, Hall. (Honeycomb coral.) W. M. No. 22,039; Bridgeport Quarry, Chicago, Illinois.

Fig. 3. *Cornulites* sp. The tube of a marine worm. Weller Coll., Joliet, Illinois.

Fig. 4. *Holocystis scutellatus*, Hall. View of a rather large specimen showing the plates; W. M. No. 12,948; near Lemont, Illinois.

Fig. 5. *Periechocrinus necis*, Winchell and Marcy. Lateral view of a slender internal cast; W. M. No. 4,634; Bridgeport Quarry, Chicago, Illinois.

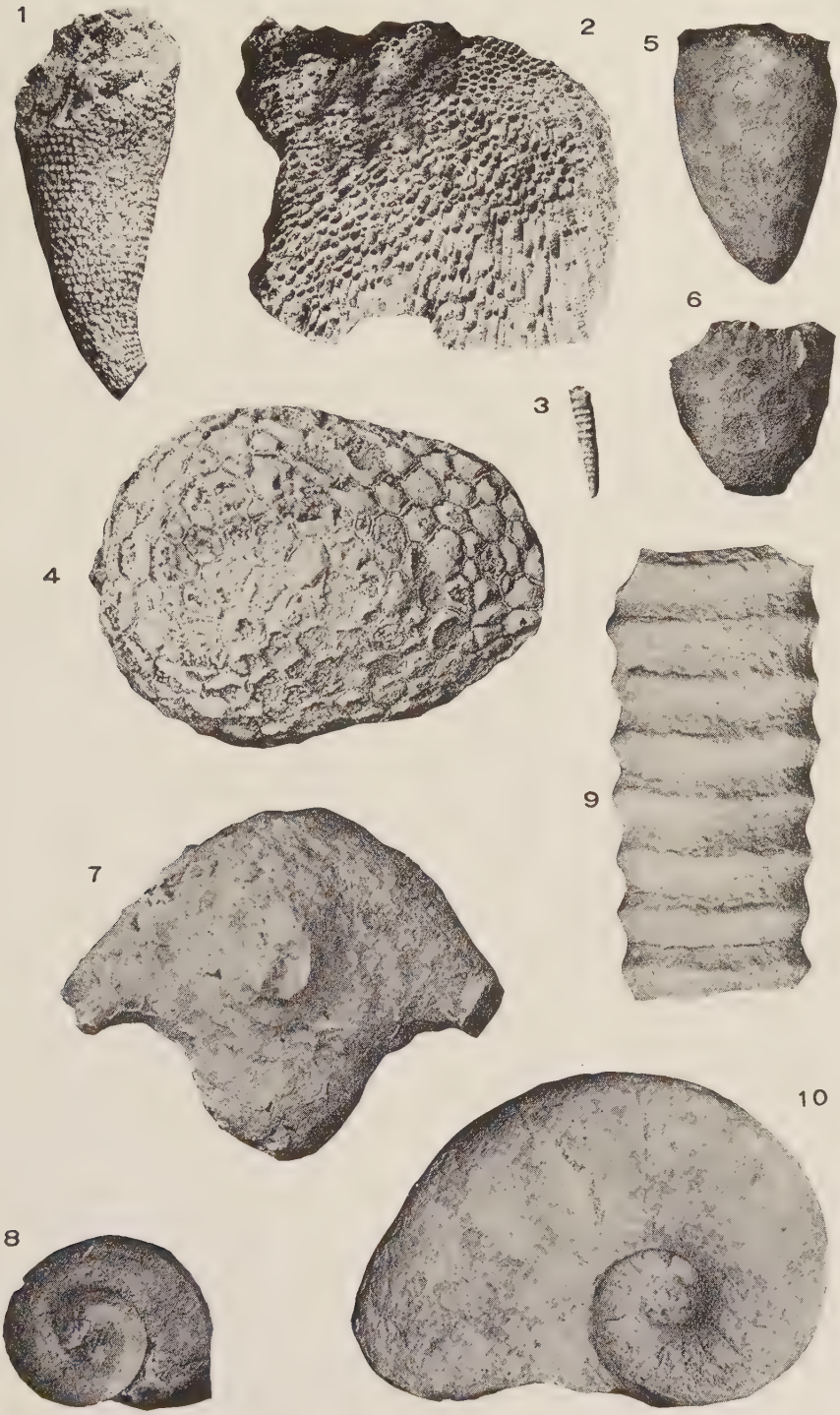
Fig. 6. *Eucalyptocrinus crassus*, Hall. Lateral view of a small internal cast. Van Horne Coll., Joliet, Illinois.

Fig. 7. *Lampterocrinus robustus*, Weller. Lateral view of a very large internal cast; W. M. No. 6,649; Romeo, Illinois.

Fig. 8. *Pleurotomaria occidens*, Hall. View of the spire of an internal cast. Van Horne Coll., Joliet, Illinois.

Fig. 9. *Dawsonoceras (Orthoceras) annulatum*, Sowerby. View of an internal cast of a flattened specimen. Van Horne Coll., Wauwatosa, Wisconsin.

Fig. 10. *Lituites cancellatum*, McChesney. W. M. No. 22,028; Joliet, Illinois.



Fossils from the Niagaran dolomite.
1, sponge; 2, coral; 3, worm; 4, cystid; 5-7, crinoids; 8, gastropod; 9-10, cephalopods. All natural size, except 2 and 10 which are ½ natural size.
Specimens from Walker Museum.

tion. The silica or chert content of the formation was relatively insoluble, and such small amounts as were dissolved would presumably be almost immediately precipitated, since, in descending, the carbonated solution would encounter fresh dolomite, and it has been shown that silica is very readily precipitated by calcium carbonate in the presence of carbon dioxide. In some such manner a large amount of dolomite has been removed, leaving behind most of the silica, which in many places has been concentrated in the very cherty upper layers of the formation. That some of the silica was not reprecipitated as chert, is indicated by the numerous silicified fossils and fossil casts found throughout the Niagaran formation, although it is possible that this silica may have come from other sources.

FOSSIL CONTENT

In certain localities the petrified remains of the shells and other hard parts of animals are abundant in the Silurian formations. Except for these few places fossils in the Joliet area are not readily secured. The heavy-bedded rock formerly quarried for dimension stone is less likely to have fossils than the thinner-bedded rock. Many quarries which were formerly worked and where fossils could be collected relatively easily are now abandoned and filled with water. It is with increasing difficulty that one can now get fossils from the "spoil banks" along the Drainage Canal, although during its excavation and shortly after, many excellent fossils were to be found. By dint of hard work however, considerable numbers of fossils can still be gathered from certain parts of the "spoil banks," especially near Romeo (sec. 35, T. 37 N., R. 10 E.) and Lemont (sec. 20, T. 37 N., R. 11 E.). The brachiopod *Stricklandinia pyriformis* is abundant in a layer near the top of the Kankakee limestone along Rock Run. Another brachiopod (*Platymerella manniensis*) can be collected from the chert layer at the base of the Kankakee formation along Du Page River.

All of the great branches of the invertebrate animal kingdom are undoubtedly represented by fossils found within the Joliet area, although the protozoans (unicellular organisms), are rarely, if ever, recognized. The corals and echinoderms (cystids and crinoids), are perhaps the most abundant, although brachiopods, trilobites (arthropods), and molluscs are not rare. One can scarcely walk a block on a Joliet sidewalk composed of slabs of dolomite without seeing many fossil remains of which the long, straight cephalopods (molluscs) are especially prominent.

The corals are of two types: the cup coral, and the honeycomb coral (Pl. V-2). Cup corals resemble the sponge shown in Plate V-1. The cystids are extinct pelmatozoans (attached echinoderms) with irregularly arranged plates (Pl. V-4). Crinoids are not extinct, and have regularly arranged plates, and well-developed movable arms. Crinoids have been

Fig. 12. Restoration of an upper Devonian crinoid (*Hallocrinus ornatissimus*, Hall). By Henri Marchand, N. Y. State Museum Bulletin 207-208, 1917.

called "stone lilies," and the appropriateness of the name is evident (fig. 12). The roots serve to anchor the animal. The stem is made up of numerous perforated, disk-like plates, which are very common as fossils, but are rarely of any value in identifying the species. Attached to the stem is the cup or calyx covered with regularly arranged plates, by means of which crinoids are classified. Next to plates of the stem, the calyx is the part of a crinoid found in most abundance. The arms are attached to the calyx and swing freely, playing an important part in getting food for the animal. As a crinoid is rooted firmly, it is dependent upon sea currents to bring its food. The photographs of crinoids shown in Plate V show only the calyx of the animal.

Brachiopod shells somewhat resemble those of present day clams, although the two animals belong to separate branches of the invertebrate kingdom. As a rule, a plane at right angles to the plane of opening of a brachiopod shell can be so located that it cuts the shell into two equal parts. This is not true of a clam shell. Clams (pelecypods) are relatively rare in the Niagaran formation near Joliet, but other molluscs, especially cephalopods, are common. Gastropods, one of which is shown in Plate V-8, are rather rare in the Joliet area, though common near Chicago. The cephalopods are of two types: those that are straight, the *Orthoceratites;* and those that are coiled. Both types are common, but the straight form shown in Plate V-9 is especially abundant. Figure 13, a restored form of the upper Devonian nautilus, shows the general appearance of a coiled cephalopod when alive. As a fossil, the shell of this animal appears similar to the one shown in Plate V-10. The straight cephalopod shell was also once occupied by a many-tentacled animal similar to that shown in figure 13. The arthropods, which include the insects, are represented by extinct crustacea known as trilobites. These derive their name from their three-lobed appearance as shown in Plate IV-13. Horseshoe crabs are perhaps their living descendants.

Mr. A. W. Slocom, of the University of Chicago, who spent the summers of 1905 and 1906 in collecting fossils from the Niagaran formation, furnished data for Table 4. It is of interest in that it gives an idea of the more numerous fossils in this formation in the Joliet area. In addition to certain forms listed in this table, the writer and his assistant found that specimens of the coral *Favosites niagarensis,* Hall, and the straight cephalopod *Dawsonoceras* (*Orthoceras*) *annulatum,* Sowerby, were fairly common.

The peculiar occurrence of Silurian fossils in clay pockets filling cavities in the dolomite near Romeo will be considered later. In the table only those species (or genera) are listed of which ten or more specimens

Fig. 13. Restoration of an upper Devonian coiled cephalopod. (*Manticoceras rhynchostoma*, Clarke). By Henri Marchand, N. Y. State Museum Bulletin 207-208, 1917.

TABLE 4.—*Fossils collected from the Niagaran dolomite*

Fossils	Total number of specimens	Romeo clay pockets	Romeo dolomite	Spoil banks near Lemont
Corals	212	212		
Amplexus, sp.		55		
Cyathophyllum, sp.		18		
Zaphrentis, sp.		74		
Lyellia americana, M-E.		42		
Cyathaxonia gainesi, Davis		23		
Cystids	159		122	37
Echinocystites sp.				15
Aethocystis nov. sp.				22
Caryocrinus ornatus, Say			47	
Holocystis scutellatus, Hall			65	
Holocystis amplus, S. A. M.			10	
Crinoids	155		130	25
Lampterocrinus inflatus, Hall			50	25
Lampterocrinus robustus, Weller			24	
Eucalyptocrinus asper, Weller			38	
Eucalyptocrinus crassus, Hall			18	
Brachiopods	70	50		20
Clorinda sp.		36		
Atrypa reticularis, Linn.		14		
Spirifer radiatus, Sow.				10
Whitfieldella nitida, Hall				10
Trilobites	96		69	27
Calymene celebra, Raymond			69	27

were secured in one summer. Most of the Romeo fossils came from the two quarries that are now abandoned and filled with water (Pl. I).

The forms pictured in Plates IV and V, along with others, lived during Silurian times in the seas which covered the present Joliet area, one of which reached up to the Hudson Bay and Arctic regions, and was probably connected with a sea of northern Europe in which deposits containing similar remains of life were laid down. The presence of corals which to-day live only in relatively warm seas where the water is shallow, in such widespread deposits, is strongly indicative of a warm climate over a broad area which included the present polar regions.

MINERAL CONTENT

Crook[16] has described 20 mineral species found in the Niagaran dolomite of the Chicago region none of which, however, are of economic im-

[16] Crook, A. R., The mineralogy of the Chicago area: The Natural History Survey of the Chicago Academy of Sciences Bull. No. 5, 1902.

portance. Of these, there are only 2 sulphides, 2 oxides, and 2 carbonates common in the area about Joliet. These minerals were formed by percolating solutions which dissolved material scattered through the rocks, and later deposited it along cracks and at other places where different solutions mingled, or where other conditions causing deposition prevailed.

SULPHIDES

Pyrite.—Pyrite is a disulphide of iron with a brassy yellow color and is harder than a knife blade. It is often in the form of cubes whose sides are marked with shallow, parallel grooves or striations. It is also known as "Fool's Gold," and where abundant, may be used in the manufacture of sulphuric acid and other products. The crystals of pyrite seen around Joliet were all small, rarely more than 1/16 of an inch in any dimension, and often showed signs of partial alteration to the hydrous oxide of iron, limonite.

Marcasite.—Marcasite has the same chemical composition as pyrite, but is a different mineral because the atoms of iron and sulphur in it have a different arrangement, as shown by the different shape of the crystals and by the fact that marcasite decomposes into limonite and other minerals more readily than pyrite. Whether the one or the other mineral is formed, according to laboratory experiments, is dependent mainly upon the temperature and acidity of the solution from which the iron sulphide crystallizes—low temperatures and high acidity favoring the formation of marcasite. The marcasite in the Silurian rocks of the Joliet area probably did not form from strongly acid solutions, as these would not be stable in the presence of abundant carbonate material.

The two minerals bear a resemblance in some cases, but can generally be distinguished by the paler color and peculiar shape of marcasite. Marcasite, instead of being in cubes, is commonly in radiating globular masses or in curved wedge-shaped crystals sometimes resembling cock's combs or spear heads. Marcasite is more common than pyrite in the Joliet area.

Galena and sphalerite.—These sulphides of lead and zinc, respectively, have been found within the Joliet area, but are very rare. Of the two, galena is the more rare. They are much softer than a knife, and in this way can readily be distinguished from all other minerals found in the dolomite except the carbonates and limonite. Galena can generally be recognized by the fact that due to its internal structure it is easily broken into small cubes.

OXIDES

Quartz. Quartz, composed of silica (silicon dioxide) next to calcite and dolomite, is the most abundant mineral in the area. About 1/6 of the solid earth, at least of that part of it near the surface which can be seen, is

made up of quartz, though this proportion may not hold for northern Illinois. Within the Joliet area, quartz appears as small crystals generally about 1/16 of an inch in length. These crystals, examined under a hand lens, are seen to be shaped like a six-sided column capped by a six sided pyramid. They are much harder than a knife blade, generally colorless and transparent, and are very common as linings in the numerous small cavities in the dolomite. Apparently these cavities were formed by solution of the dolomite by percolating waters, and later other solutions deposited the quartz crystals in them.

Chert, which has been described previously, may be considered a variety of quartz, since it also is composed of silica, although it commonly contains a little water in addition. Some of the silica present in the small cavities in the dolomite of the Joliet area is the hydrous variety known as opal. This generally has smooth, gently rounded surfaces, and it looks quite like shiny drops of glass.

Limonite.—Limonite is a hydrous ferric (iron) oxide which is readily distinguished from all other minerals found in the dolomite by the color of its powder or streak, which is a characteristic yellowish-brown. Although commonly about as hard as a knife, it is sometimes much softer than galena or sphalerite. It often appears as a yellow stain along the joint planes of the dolomite. The buff color of the upper part of the dolomite, which is so different from the blue-gray fresh material that comes from the quarries, is probably due to the presence of small amounts of limonite. It commonly forms by the oxidation and hydration of other iron minerals, especially pyrite and marcasite, and may sometimes be seen coating them.

CARBONATES

Calcite.—Calcite, the carbonate of calcium, is sometimes found in cavities in the dolomite; rarely in crystals an inch or two across. These crystals are almost always white rhombohedrons, which are forms that resemble distorted cubes. The rhombohedrons of calcite that were seen in the area all had curved faces.

Calcite can be scratched with a penny, and if touched with cold, dilute hydrochloric (muriatic) acid, it readily effervesces, as bubbles of carbon dioxide gas are formed. It can also be split or cleaved into rhombohedrons just as galena can be split into cubes.

Dolomite.—The term *dolomite* may be used to denote a mineral or a rock. The mineral dolomite is a double salt, that is, a carbonate of both calcium and magnesium. It contains 54.35 per cent calcium carbonate and 45.65 per cent magnesium carbonate. No samples of the mineral dolomite, large enough to be recognized as such without a microscope, were seen in the Joliet area. The rock dolomite to which reference is made wherever dolo-

mite is mentioned in this report, is also made up of calcium and magnesium carbonates, but rarely contains as much as 45.65 per cent magnesium carbonate. In various districts there are rocks which show all gradations between a pure limestone, calcium carbonate, and a pure dolomite. Where the percentage of magnesium carbonate is greater than 40 and the remainder is largely calcium carbonate, a rock should be called a dolomite. In this sense, the Niagaran formation of the Joliet area is dolomite, as shown by the analyses on page 33. Dolomite, like calcite, effervesces in acid, but generally requires warm or concentrated acid. It is slightly harder and heavier than calcite.

CHAPTER IV.—POST-SILURIAN, PRE-GLACIAL HISTORY

All known consolidated rocks occurring within the Joliet area are of early to mid-Paleozoic age, with the exception of some of the Pleistocene deposits which cover the bed rock. At the time the oldest known rocks of the Joliet region were formed, life was abundant, all branches of invertebrate animals were represented, and apparently the earth had maintained an environment suitable for the existence of life for many millions of years previously. Thus the early history of the area is recorded in rocks buried too deeply by Paleozoic sediments to be of any value to us at present. Only by analogy with other areas where older rocks are exposed can the record be interpreted. The history of the area as recorded in the Paleozoic rocks encountered has been presented previously along with descriptions of the rocks, breaks in sedimentation, and the life forms that flourished. There remains for consideration that great interval of time represented by no solid rock formations now found within the Joliet area; that is, the time from the close of the Niagaran epoch to the Pleistocene period, when great ice sheets advanced over the area. This includes probably at least half the Paleozoic era, the whole Mesozoic era, and all of Tertiary time (see page 19). Very little is known about the history of this area during these ages, and for what little is known, we are dependent mainly upon the record read from rocks present in other areas.

After the Niagaran sea withdrew from the area, land conditions with consequent erosion of the newly-formed sediments, probably obtained until well on into the Devonian. In the upper Devonian epoch a sea invaded the region. The nearest Devonian rocks, if the buried Indiana rocks are excepted, are at Milwaukee, Wisconsin, and at Rock Island, Illinois. However, the finding of fish-teeth and other fossils of late Devonian or early Mississippian age in clay-breccia pockets in cracks in the Niagaran formation in quarries at Elmhurst (DuPage County) and elsewhere in the vicinity, proves that a sea covered the area at this time. Weller[1] has described one of these occurrences, where the fossils are 18 feet below the present glaciated surface of the Niagaran dolomite.

Following this late Devonian or early Mississippian submergence, it is probable that land conditions again prevailed, although the subsequent history of the region is not clear. There were probably one or more submergences during the Mississippian period, and it is probable that early Pennsylvanian sediments also were deposited in the area. The Pennsyl-

[1] Weller, Stuart, A peculiar Devonian deposit in northeastern Illinois: Journal of Geology, vol. 7, pp. 483-488, 1899.

vanian period is distinguished in at least three continents by great deposits of coal, which were formed mainly in swamps, although marine limestones are interbedded with the coal, showing that at times the sea covered the land. However, no remnants of Mississippian or Pennsylvanian strata have ever been found within the Joliet area, and sediments, if deposited in these periods, have been completely removed as far as has been observed. In this connection, the logs of wells No. 175 and No. 295 (Table 8) are of interest, since the drillers reported encountering coal. Whether these are mistakes in identification, or really represent outliers of Pennsylvanian strata is not certain. The nearest known Pennsylvanian outcrops are 8 miles southwest of Joliet in sections 20 and 24 of Channahon Twp. (T. 34 N., R. 9 E.).

There is no evidence to show that the area was under the sea after the Pennsylvanian period. Probably rivers and winds caused deposition of some

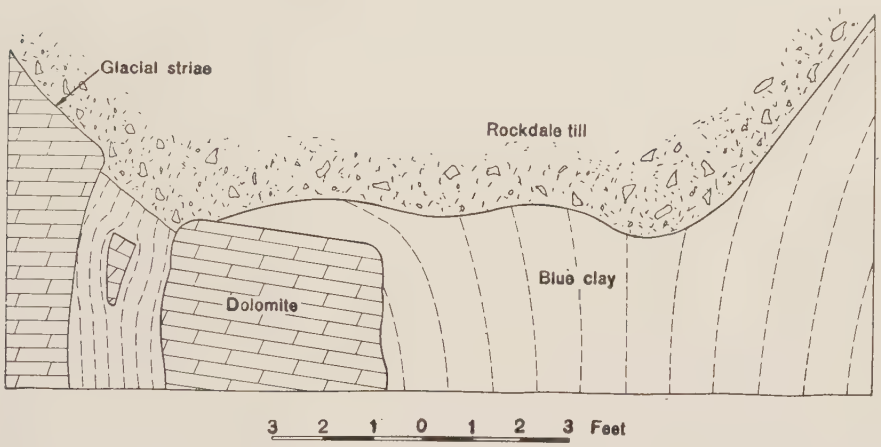


Fig. 14. Section at Jefferson and Broadway Streets, Joliet, showing Rockdale till resting on blue clay and dolomite.

material, but between the Pennsylvanian and the Pleistocene periods, erosion, rather than deposition, was the dominant process in the area concerned.

That some deposits were formed during this interval is indicated by the presence of a homogeneous, light bluish-gray, non-calcareous clay found at certain localities in the Joliet area. It occurs in irregular pockets or channels in the dolomite which are sometimes smoothed as if by corrasive action of water. A description of its character and mode of occurrence at a few localities is given.

1. The blue clay was first observed in a pocket in the dolomite on Jefferson Street, Joliet, at the Broadway Street bridge. It is there overlain by till of Rockdale age, and is therefore older than this drift sheet. The general relations observed on the south side of Jefferson Street are shown

diagrammatically in figure 14. The broken lines in the diagram indicate parting in the clay. The sheets are about ⅛ of an inch thick, separated by more or less curved surfaces which appear to be due to downward movement under pressure.

The smaller fragment of dolomite measures about a foot along its greatest dimension; its surfaces are very smooth as far as can be seen; and apparently the smoothing was done by water. The cleavage in the blue clay surrounding it is nearly vertical, and seems to wind about the fragment. The clay at this point is plastic and fat. At all points the clay is overlain by till, the contact being sharp. Just to the right (west) of this small fragment is a large block of dolomite five feet thick in a horizontal east-west line. To the right of this block nothing but blue clay is exposed as far as the section showed. Here the clay is less plastic, in places being even slightly granular, and the parting surfaces are farther apart. A few white streaks in it at irregular intervals, but all parallel to the parting, are calcareous. The surface of the dolomite in place at the extreme left is marked with what appear to be glacial striae, having a bearing of S. 60° W. The yellow till, ranging from 2 to 6 feet in thickness, is overlain, with a sharp contact, by some 4 feet of very poorly assorted gravelly material, not shown in the diagram, the upper part of which is leached. A small patch of the blue clay could be seen on the north side of Jefferson Street bearing out the report of the city engineer that it extended under the street. He also stated that it was common to meet pockets of such blue clay wherever excavations were made in the dolomite. On the whole, this occurrence resembles an irregular pocket in the dolomite into which blue clay containing a few fragments and blocks of dolomite has been dropped from above.

2. Another occurrence of this light-blue clay was noted in the abandoned quarry a few hundred yards north of Fraction Run in the SE. ¼ NE. ¼ sec. 27, T. 36 N., R. 10 E. (Pl. I). The blue clay here is massive and non-calcareous and is in two vertical fissures, each about 2 feet wide. It contains numerous small angular fragments of chert and a few blocks of dolomite more than a foot square in cross section. The deposit looks much like blue till, but differs in that it is non-calcareous, is lighter in color, and contains only chert fragments and the large blocks of dolomite, while the neighboring dolomite is practically chert-free. There is some evidence that minor faulting has taken place along these fissures but, if so, the vertical displacement was not more than 2 feet.

3. Minor pockets of blue clay were noted in the dolomite along the northwest bank of Du Page River a short distance southwest of Grinton.

4. Slocom[2] has described and pictured deposits of this blue clay which

[2] Slocom, A. W., New crinoids from the Chicago area: Field Columbian Museum Pub. No. 123, pp. 273-274, 1907.

were seen in the quarry at Romeo, now filled with water. Silicified Silurian fossils were abundant near the bottom of the large clay pockets. They were of types not seen in the neighboring dolomite, but found in the rock near Lemont five miles up the valley. To quote from Slocom:

"These clay pockets occupy large, irregularly shaped cavities in the limestone. The larger ones are 15 or more feet deep and their width is often greater than their depth. In some instances several are connected, their connections following the jointing of the limestone. These cavities, or 'pot-holes' as they are sometimes called, often associated with furrows, are to be seen in many places along the Chicago Drainage Canal where the surface of the rock is exposed. The cavities vary in size from a fraction of an inch in depth to those mentioned above. These cavities or pot-holes must have been in part subjected to the action of running water since their sides are smooth. They are frequently broader at the base than above and may even be cone-shaped, with the apex of the cone above. Their filling is for the most part a blue homogeneous clay. This contains small silicified fossils of Niagaran age, small, modern fresh-water shells and fragments of pyritized and charred wood. No large boulders or pebbles occur in the clay, although these frequently form a capping of the pockets. The question of the origin of the filling of the pockets is a matter of no little interest. The clay could not be of pre-glacial origin because of its content of wood and modern shells. If of post-glacial origin, the presence of the Niagaran fossils is difficult to account for. * * * The silt-like nature of the deposit in the clay pockets shows that it occurred in quiet waters."

Thus it would seem that all of the "blue clay" of the area did not originate in the same epoch, since the Joliet occurrence sketched in figure 14 is of pre-glacial or interglacial origin, while the Romeo clay seems to be of post-glacial origin, although Mr. Slocom[3] considers it possible that the modern shells were washed in from the neighboring marl beds, in which they are abundant, subsequent to the formation of the blue clay.

5. Another significant occurrence of this blue clay was noted at the quarry of the National Stone Company just south of Joliet in the east part of section 21, T. 35 N., R. 10 E. It is found here in irregular channels and cavities, many of which appear to be water-smoothed. Figure 15 shows a view of this quarry. In about the center between top and bottom, but at the extreme right edge, one-half of an apparently obconical pot-hole-like cavity can be seen in the south wall of the quarry about 50 yards east of the crushing building. The cavity is shown in more detail in figure 16. It is a little more than 20 feet deep, and if it was circular at the top, its diameter there was about 15 feet. It was once filled with

[3] Personal communication.

blue clay, according to Mr. George Langford of Joliet, who had collected Silurian fossils from it. The walls of the cavity are very smooth, apparently due in large part to water action. It is reported that the present top of the hole is 17 feet below the level of the dolomite before quarrying operations were started and that the presence of a heterogeneous mixture of blue clay and blocks of dolomite above this hole made quarrying most difficult.

Similar masses can be seen on the south side of the quarry, and it is possible that they may overlie similar holes. The masses still present contain great blocks of dolomite—some more than 3 feet through—which, while noticeably sub-angular, all show one or more sides worn smooth by water action. On the east side of the quarry a distinct channel filled with blue clay was traced for 50 yards. The sides of the channel were

Fig. 15. Quarry of the National Stone Company, Joliet. Note large cavity shown by arrow at right.

smoothed, at least in part, by water action, and the blue clay contained blocks of dolomite smoothed on one or more sides. The size of this channel is variable, but is as much as 10 feet wide and 15 feet deep. On the whole it resembles closely those described near Ottawa by Sauer,[4] although the latter are somewhat smaller. Sauer attributes the origin of the channels to ice action followed by subsequent water action, and it is possible that the channel seen near Joliet originated in the same manner. The channels described by Sauer are less than 40 feet above the present river level, and are in the Illinois Valley. The channel at the National Stone Company's quarry is about 55 feet above the present river level.

[4] Sauer, C. O., Geography of the Upper Illinois Valley: Ill. State Geol. Survey Bull. 27, pp. 91-94, 1916.

6. At the quarry of the Lehigh Stone Company, seven miles west of Kankakee, cavities containing a similar light blue clay were observed in the Niagaran dolomite. At this quarry some of the cavities, instead of containing the bluish clay, are filled with more or less horizontally-bedded, finely laminated, dark gray Pennsylvanian shales. These shales contain small amounts of coal and charcoal and plant remains, and are perhaps of Pottsville (early Pennsylvanian) age. They are in place, and were

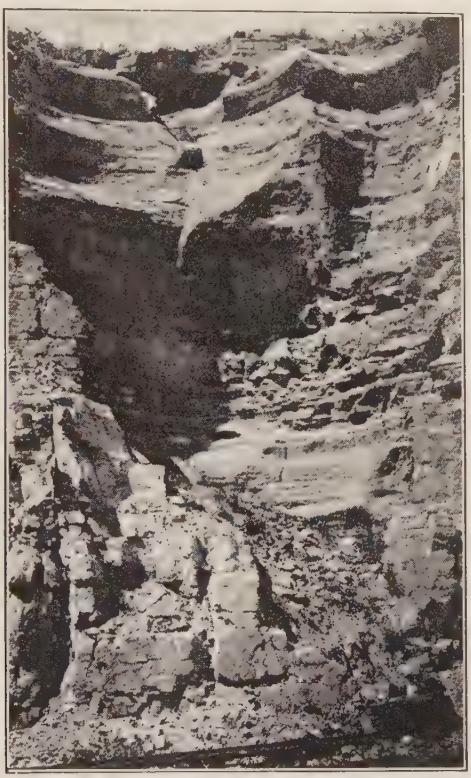


Fig. 16. Detailed view of cavity in the quarry of the National Stone Company, Joliet. (Photograph by Walter Hollensteiner.)

deposited during the Pennsylvanian period in sink holes developed in the Niagaran dolomite during the late Silurian and the Devonian and Mississippian periods. Where observed in these sink holes, the Pennsylvanian shales abut directly against the Niagaran dolomite, as if the sink holes lacked debris at the time the shales were being deposited. Interbedded with these shales are occasional small lenticular masses of light greenish gray

shale. Fragments of material of this color were observed in the light blue clay of some of the cavities, indicating that at least in part this clay is composed of Pennsylvanian material.

7. In the spring of 1924, Professor R. T. Chamberlin noted a new occurrence of the clay exposed in an excavation in the Niagaran dolomite for the basement of a building in the city of Joliet. The clay pocket appeared in the north wall of the excavation along the south side of Clinton Street, just west of Scott Street. The occurrence here is unique in that the clay is laminated. Except for the laminations, however, the material bears no resemblance to the Pennsylvanian shales seen in similar pockets at the quarry of the Lehigh Stone Company.

Figure 17 shows a general view of the phenomenon. The boundary of the pocket is outlined for the sake of clarity. The 14-foot section exposed here is as follows:

Exposure of clay in Niagaran dolomite in Joliet

Age	Material	Thickness *Feet*
Recent		
	5. Soil	1
Pleistocene		
	4. Gravel, containing slabs of dolomite up to 6 by 6 by 1 inches	1–2
Post-Niagaran but pre-Pleistocene		
	3. Massive, light-gray, chalky-appearing, non-calcareous material, containing numerous chert nodules (between dashed lines in fig. 17.)	4
	2. Clay and silt (maximum)	6
Niagaran		
	1. Dolomite	1–12

Number 2 of the above section is shown in more detail in figure 18. It is largely made up of bluish, non-calcareous, laminated, plastic clay. Under the microscope, this is seen to be made up entirely of hydrous aluminum silicate materials—kaolin, white mica, or hydromica (beidellite?). It fuses readily before the blowpipe to a glass of the same color. After drying, it slakes to a fine powder in water, but does not absorb water and form a gel as does bentonite.

The dip of the laminations in No. 2 of the above section varies from horizontal to a maximum of 40° in the plane of the section. The true dip is probably as great as 45° in a northerly direction at one place. Such a dip, which is primary, may be due to a swirling of waters in a bowl-like cavity as suggested by Dr. MacClintock, or may be simply a depositional dip in quiet waters with the amount of dip corresponding closely to the attitude of the floor of the "bowl". The dip is much greater in the lower part of the section than in the upper part.

Interbedded with this plastic clay are a few thin layers, .5 inches in maximum thickness, of brittle siltstone which can be seen in figure 18 making minor ledges. It is light gray, non-calcareous, and made up of the same materials as the plastic clay, but also contains about 25 per cent of quartz in fine irregular grains. The section also shows a few thin bands of a pale lilac color.

The cavity has a maximum exposed width of 14 feet, and its walls are notably smoothed, due to corrasive or corrosive action of water. Silici-

Fig. 17. General view of bluish clay pocket, Clinton Street, Joliet. (Photograph by Paul MacClintock.)

fied fossils found in No. 2 of the above section as determined by Professor Weller include:

Brachiopods
- Spirifer radiatus
- Atrypa reticularis
- Pentamerid (Clorinda sp. ?)
- Orthid (cf. Rhipidomella sp.)

Siphuncle of an Orthoceratite
Fragment of a horn coral
High-spire gastropod

Professor J H. Bretz[5], of the University of Chicago, attributes the cavities containing blue clay to solution of the dolomite along joint planes by ground waters, and thinks the blue clay is in part the insoluble residue left from leaching of the overlying dolomite. This appears logical, since

[5] Personal communication.

the blue clay underlies the Rockdale till and is therefore pre-Rockdale (and probably largely pre-Pleistocene); and since the analyses of the Niagaran dolomite given on p. 33 show an average of 3½ per cent of relatively in-

Fig. 18. Detailed view of bluish clay pocket, Clinton Street, Joliet. (Photograph by Paul MacClintock.)

soluble material, largely silica, no great amount of dolomite is necessary to account for the relatively small amount of blue clay observed. Thus it seems

probable that this blue clay is the only geologic deposit in the area representing the last half of the Paleozoic, and the Mesozoic and Tertiary time.

During this long post-Silurian interval, great events were taking place, as is indicated in other regions. In Devonian time, fishes (vertebrates) first became an important branch of the fauna. These were soon followed by amphibians, animals that live part of their lives in water, part on land. By this time, the land, which in the earlier Paleozoic had perhaps been more or less bare, gradually became covered with verdure, and in the Pennsylvanian period, forests covered much of the land. Their accumulated remains produced our present great coal beds. Amphibians gave way to reptiles, which first appeared in the late Paleozoic, dominating the world through most of the Mesozoic era. During this age dinosaurs and flying reptiles (pterodactyls) had their maximum development and decline. Mammals, which appeared early in the Mesozoic, gained ascendancy over the reptiles about the beginning of the Cenozoic, when grass first began to cover the soil. Finally in the late Tertiary or early Pleistocene, man appeared, millions of years after the disappearance of the last dinosaur. In North America, there is no good evidence of the existence of man until after the last glacial epoch, but in Europe his relics have been found far back in the Pleistocene, and possibly even in the Pliocene (late Tertiary). About this time a period of cold set in, and great ice-sheets buried a large part of North America, Europe, and Greenland, ushering in the Pleistocene period.

CHAPTER V.—GLACIAL GEOLOGY

Introduction

GLACIATION IN NORTH AMERICA

Within the last half century, careful study by geologists has shown the presence of a body of unconsolidated material called *drift* covering a large part of north-central and eastern United States and much of Canada. This deposit is unlike any type of deposit now forming, with the exception of that accumulating under the ice of existing glaciers. Greenland, which is largely covered by an ice-sheet, has been visited by geologists, and the types of deposits made by ice have been studied.

Thus the conception that most of Illinois and of neighboring states (except on the south) was once covered by an ice-sheet such as now covers Greenland, has been accepted by all who have thoroughly investigated the subject. Careful, painstaking work over several decades and in wide areas has established the fact that not only has one ice-sheet covered the area mentioned, but that as many as five distinct ice-sheets have covered large parts of this area successively. Why a great ice-sheet should form and slowly deploy over millions of square miles, and finally "retreat" by melting and evaporation—and why some five great ice-sheets within one geological period should do the same thing, is a question that has not been satisfactorily answered. There are many theories to explain why and how this happened, but none of them is universally accepted, and none will be presented here. It is equally difficult to explain the sub-tropical climate which prevailed even in polar regions during Silurian times. The fact remains that in both cases types of deposits were formed which have never been satisfactorily explained except on the basis of the temperature conditions indicated. Formations within the boundaries of the Joliet area prove that it was once covered by at least one of these great ice-sheets, and studies in surrounding regions make clear that it probably was affected by all five.

Figure 19 shows the standard conception of the largest ice-sheet which, accumulating at three main centers, the Labrador in northeastern Canada, the Keewatin just west of Hudson Bay, and the Cordilleran in the Canadian Rockies, deployed in all directions. The ice from these centers merged and extended into the United States to the limits of the glaciated area. A small area in southwestern Wisconsin and adjacent states was untouched by any of the great ice-sheets, and is known as "The Driftless Area".

CRITERIA OF GLACIATION

The evidence on which this conception is founded may be divided into two classes: (1) that furnished by the deposits of drift and (2) that furnished by certain erosional features of the rock beneath the drift.

DEPOSITS

The map (Pl. I) shows that much of the area is covered by a body of unconsolidated material known as drift, deposited by the ice-sheet and the waters formed by its melting. In thickness, this drift ranges from a few feet up to 160 feet within the Joliet area. Elsewhere it is known to

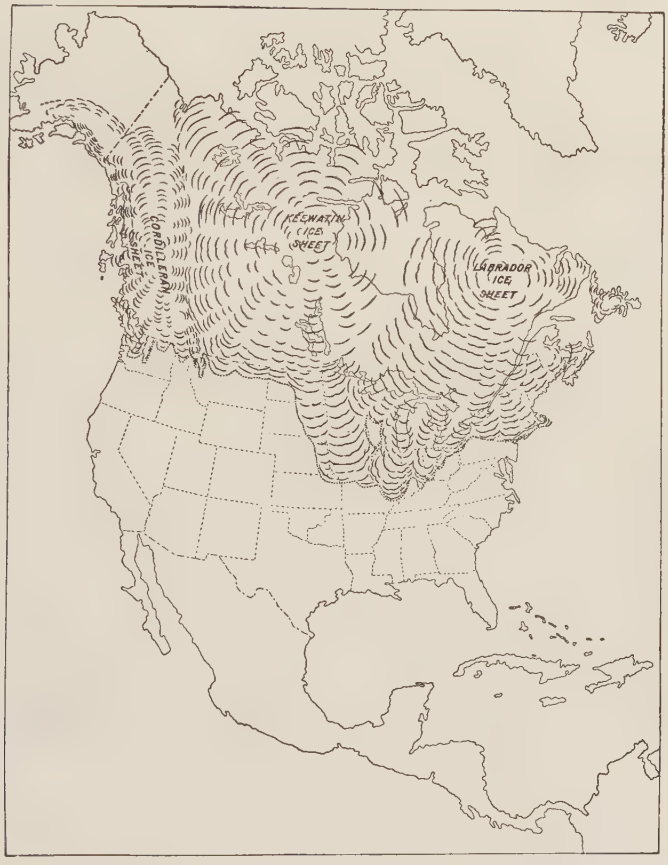


Fig. 19. Sketch map of North America, showing the area covered by the ice sheets during the glacial period. The dotted black line represents the approximate maximum extent of the ice. The centers from which the ice moved, the general direction of the movement and the driftless area are also roughly shown. (U. S. Geol. Survey.)

exceed 500 feet in thickness. It is made up of heterogeneous material, largely of clay, sand, stones and boulders derived from the underlying rock, or from rock underlying areas to the northeast. Many boulders are from rock formations not known to be in place within several hundred miles.

The drift may be subdivided into two classes: (1) the unstratified, or that which shows no definite arrangement of particles, known as till, and (2) the stratified (fig. 20), consisting largely of sand and gravel, mostly deposited in front of the ice by the waters issuing from it. It is however, also found as pockets or layers in the till, or as ridges and hillocks on its surface.

Most of the drift of the region is till, a very heterogeneous mixture of particles varying in size from those of fine clay to huge boulders. Figure 21 shows a syenite (granite without quartz) boulder 4 by 3 feet in diameter, projecting out 2 feet from the clay bank, on the north side of the ravine just south of Maple Avenue in section 11, Joliet Twp. (T. 35 N., R. 10 E.), less than half a mile east of the Elgin, Joliet and Eastern Railroad

Fig. 20. Section of stratified drift, gravel pit in the NE. ¼ of section 28, Du Page Twp. (T. 37 N., R. 10 E.).

yards. It is surrounded on all sides by yellowish clay, almost free from stones. The photograph also illustrates a type of weathering commonly shown by the igneous rock boulders of the till; namely, exfoliation into curved plates that look like parts of a thin spherical shell. The nearest known outcrop of syenite is several hundred miles to the north. This fact, combined with the occurrence of such a large boulder surrounded by unstratified clay ruling out the possibility of wind or water as the depositing agent, is strong evidence of the glacial origin of till. Present-day glaciers are making deposits similar to this. Figure 22 shows a large boulder (8 by 6 by 4 feet), composed of fine-grained basic igneous rock, in an abandoned quarry just northeast of the steel mills in section 3, Joliet Twp.

(T. 35 N., R. 10 E.). Although not now surrounded by till, it unquestionably was brought to this region by the ice-sheet.

Sub-angular pebbles and stones are common in the till of the area, and were formed by the rubbing together of materials held firmly by the

Fig. 21. Syenite boulder in till.

ice. Some such stones show marks or grooves in parallel sets which are called striae (fig. 23).

The distribution, heterogeneity, and irregularities in thickness of the drift can be explained only by ice-action. In some places the surface of the

drift is higher above the valleys in the bed rock than it is above the rock hills. In places the surface of the drift is much rougher than the surface of the underlying rock. The surface of the drift contains numerous undrained depressions, shown by contours at several places on the map. Where the contact between the drift and the underlying bed rock is exposed, the surface of the dolomite is fresh, and there is no gradation between bed rock and overlying drift, such as shown in driftless areas where the surface earths come from the decay of the rock beneath. This is additional conclusive evidence that at some past date this area was buried by a great ice-sheet.

Fig. 22. A large glacial erratic (a boulder composed of a type of rock not outcropping in the Joliet area), which has been transported several hundred miles by the moving ice.

EROSIONAL FEATURES

In the broad valley of the Des Plaines, just across the river from Lemont in the center of the SE. ¼ of the SW. ¼ of section 17, Downer's Grove Twp. (T. 37 N., R. 11 E.), on the dolomite bed of a small tributary creek, parallel scratches (fig. 23) were observed which had a bearing S. 55° W. These striae were made by stones held rigidly by the ice-sheet as it passed over this bed rock surface. Striae have been seen at nearby localities. These are the main erosional features of glaciation observable within the Joliet area.

SUMMARY

Water, wind, and ice in motion are the only known agencies capable of forming such a widespread deposit as the drift of the region. Its

irregular distribution, over hills and valleys alike, as well as the unstratified character of the till, prove that it could not have been formed by water. Wind could not have transported large boulders. Glacial ice alone could have made such a deposit, in fact, is making such deposits in Greenland[1] now.

COMPOSITION OF THE DRIFT

The rocks commonly found in the glacial drift are of three types, sedimentary, igneous, and metamorphic. Sedimentary rocks, and the minerals of which they are composed, are described briefly in Chapters III and IV. Igneous rocks are not known to outcrop in the Joliet region, nor elsewhere in

Fig. 23. Glacial striae on dolomite in bottom of ravine in SE. ¼ SW. ¼ sec. 17, T. 37 N., R. 11 E. (Photograph by John Doering).

northern Illinois. They are rocks which were once in a liquid condition, but solidified on cooling. Lavas coming from volcanoes cool and form igneous rocks of which there are many different kinds, although only three types are common in the drift of the Joliet area. These are granites, syenites, and dolerites (diorites, gabbros, and diabases). Metamorphic rocks are changed sedimentary or igneous rocks. Gneisses are rocks of this type resembling granites, but with a banded appearance. Figure 24 shows an area in the south-central part of section 2, Troy Twp. (T. 35 N., R. 9 E.) thickly

[1] Alden, W. C., U. S. Geol. Survey Atlas, Chicago Folio (No. 81), 1901. See fig. 19.

covered with boulders taken out of a near by gravel pit. These boulders average about a foot and a half in diameter, and are mostly dolerites, which are dark, nearly black rocks. Of 244 boulders counted in this pile, 208 were dolerites (36 of these were rather fine-grained), 20 granites and syenites, 13 dolomites, and 3 gneisses. At a point half a mile to the northeast, 36 boulders about a foot in diameter were counted, of which 26 were dolerites, 4 syenites, 3 granites, and 3 gneisses.

Fig. 24. Igneous boulders from the glacial drift in sec. 2, Troy Township (T. 35 N., R. 9 E.).

GLACIAL EPOCHS

Beginning with the oldest known glacial advance as No. I, the various epochs of the Pleistocene or Glacial period are listed in the following table.

TABLE 5.—*Epochs of the Pleistocene period*

No. XI.	The Champlain sub-epoch (Marine)
No. X	The Glacio-lacustrine sub-epoch
No. IX.	The Wisconsin (the fifth advance of the ice)
No. VIII.	The Peorian (the fourth interglacial interval)
No. VII.	The Iowan (the fourth advance of the ice)
No. VI.	The Sangamon (the third interglacial interval)
No. V.	The Illinoian (the third advance of the ice)
No. IV.	The Yarmouth (the second interglacial interval)
No. III.	The Kansan (the second advance of the ice)
No. II.	The Aftonian (the first interglacial interval)
No. I.	The Sub-Aftonian (the first advance of the ice)

These epochs of the Pleistocene were not all of equal duration, the earlier ones probably being much longer than the later. Estimates of the duration of the Pleistocene period vary greatly, but probably the average would be about a million years. Following the last advance (Wisconsin), certain sub-epochs have been recognized. There probably were analogous sub-epochs after each advance, but those following all but the last have been so completely obliterated by later ice advances that they have not been recognized. Moreover, since the last advance left deposits which have been less changed, the tendency is to work out its history in much greater detail. The reader should not therefore get the impression that the Wisconsin stage is the most important. Because the deposits of Wisconsin age can be recognized with certainty in the Joliet area, the history of the advance of the Wisconsin ice-sheet is more easily read from phenomena now observed in this district. The apparent absence of pre-Wisconsin drift deposits in the Joliet area is the result of obliteration or burial of the record of earlier advances by the Wisconsin which is generally thought to have been the shortest of the glacial epochs.

WISCONSIN GLACIATION IN ILLINOIS

The deposits made by the ice-sheet of the Wisconsin epoch, known as the Wisconsin drift series, have been divided into several formations, grouped in two major divisions, the Early and the Late Wisconsin. These terms are convenient in designating and separating groups of drift sheets. Used in this sense, they are valuable, since they give general ideas for this part of Illinois of fairly definite sub-epochs of the last glacial epoch.

The deposits made by an ice-sheet may be divided into three classes (fig. 25): that made under the body of the ice, called ground moraine, (B); that under the edge of the ice, or terminal moraine, (C); and that made beyond the edge of the ice and deposited by the waters flowing from the melting ice, known as outwash, (F). Drift is a term including all three classes of deposits. The following list shows the drift sheets deposited during the Wisconsin epoch in Illinois.

TABLE 6.—*Drift formations of the Wisconsin epoch*

8.	Lake Border	Late Wisconsin sub-epoch
7.	Valparaiso	
6.	Rockdale	
5.	Minooka[a]	
4.	Marseilles	Early Wisconsin sub-epoch
3.	Bloomington	
2.	Champaign	
1.	Shelbyville	

[a] There is some doubt as to whether the Minooka belongs with the Early or the Late Wisconsin, but it is a point of minor importance so far as this bulletin is concerned.

Of these eight formations, the Shelbyville, Bloomington, Marseilles, and Valparaiso are much more pronounced topographically than are the other four. The Valparaiso is the most pronounced. Figure 26 shows the location of the terminal moraines formed during these stages. The terminal moraines merely border the various drift sheets, which are largely made up of ground moraine. In general, a terminal moraine is considerably thicker than the ground moraine behind it. Figure 27 shows the sequence of events which took place during the Late Wisconsin sub-epoch. After the forma-

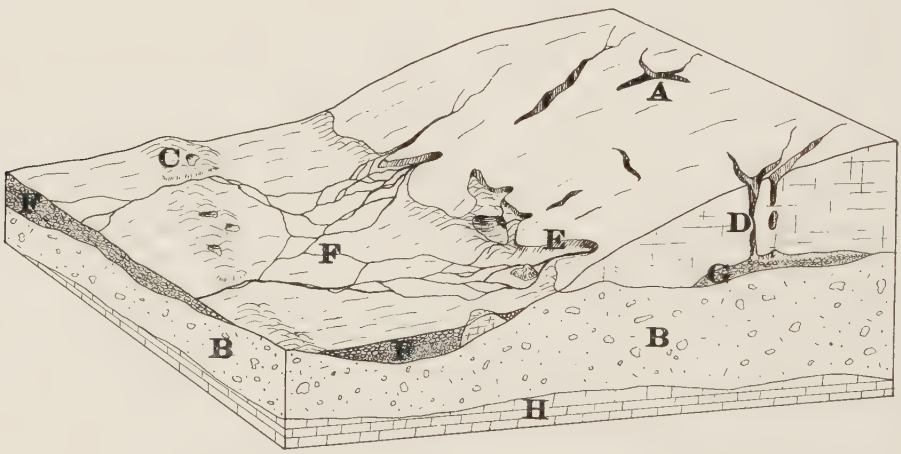


Fig. 25. Block diagram illustrating the mode of origin of deposits made by an ice sheet.

A. Glacial ice.
B. Ground moraine deposited by glacial ice.
C. Ridged drift or terminal moraine, abandoned by retreat of the ice. Similar ridged drift is shown at and under the existing edge of the ice.
D. Super-glacial streams descending to become sub-glacial.
E. Sub-glacial stream emerging from tunnel, a situation where kames are formed.
F. Outwash plain deposited by heavily loaded fluvio-glacial streams.
G. Fluvio-glacial deposits under the ice. These may give rise to eskers after melting of the ice.
H. Bed rock.

tion of the Marseilles and earlier drifts, the ice-sheet retreated an unknown distance to the northeast. Later the ice advanced to the southwest until its edge was along the position of the Minooka till ridge (fig. 27). Most of the Early Wisconsin ground moraine under the Minooka ice was probably destroyed by it, with the exception of that under the edge of the ice-sheet, where deposition exceeded erosion. However, isolated masses of Early Wisconsin drift such as is indicated in the diagram (fig. 27) were

probably left some distance to the northeast. Following the formation of the Minooka till ridge under the edge of the ice-sheet, and the Minooka ground moraine under its body, the glacier retreated northeast a considerable distance beyond Joliet. Eventually the ice again advanced and the Rockdale moraine was formed. Following this, the ice retreated and next as-

Fig. 26. Map showing the moraines in northeastern Illinois. (After Leverett and Leighton.)

sumed a constant position when its edge was above the site of the Valparaiso terminal moraine. That it maintained this position for a relatively long time is shown by the massive ridge formed under its edge. Later, after another retreat, the diminutive (in Illinois) Lake Border moraine was formed, and Illinois has since been free from ice-sheets.

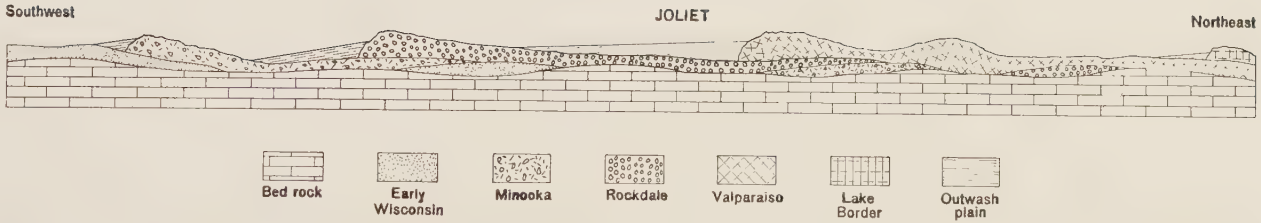


Fig. 27. Idealized diagrammatic cross-section through Cook, Will, and Grundy counties, showing the relation of the several sheets of drift to one another. Remnants of any drift sheet are likely to exist beneath later drift sheets at almost any point. Vertical scale greatly exaggerated.

No definite evidence of drift belonging to the Shelbyville or Champaign stages of the Early Wisconsin sub-epoch within the Joliet area was observed. The Bloomington drift was recognized in the Joliet area, although the younger Marseilles drift was not. There are abundant exposures in the Joliet quadrangle of all of the Late Wisconsin drift formations older than the Lake Border morainic system.

Pleistocene Formations in the Joliet Quadrangle

BLOOMINGTON DRIFT FORMATION

By reference to the map (fig. 26) the Bloomington terminal moraine is seen to be the most westerly of any of Wisconsin age in Illinois. Wherever fresh till of this stage is found in Illinois, it is characterized by its pinkish color. Just why this is the only one of the drift sheets of the Early Wisconsin sub-epoch which shows this pink color is not definitely known. The color is presumably due to the presence of ferric oxide. Perhaps the ice-sheet of the Bloomington stage passed over rocks rich in this compound, grinding them up to form the pink till, whereas earlier and later moraines in Illinois were formed by ice-sheets which did not have access to the particular iron-rich formation responsible for the color.

In the southwest corner of the Joliet quadrangle in the NW. ¼ section 21, Troy Twp. (T. 35 N., R. 9 E.) in the north bank of the creek tributary to Du Page River (Pl. I), there is a two-foot section of highly calcareous pink till underlying about 4 feet of laminated lake clays, which are overlain by till of Minooka age. This pink till is thought to be of Bloomington age. It is an inlying remnant more than 15 miles from the nearest large body of exposed Bloomington drift to the northwest and is one of the farthest east exposures of Bloomington till in Illinois, north of the 41st parallel.

LAKE DEPOSITS

Clays, silts, and sands which show by their constitution and structure that they were deposited in lakes or essentially quiet bodies of water are known at the following localities within the Joliet quadrangle. Wherever the base of these deposits was seen, it was on Early Wisconsin till or Silurian dolomite. In all cases the lake deposits are underneath till of Late Wisconsin age, except at localities C and E, where no till is found and gravel overlies the lake clays. It has not been demonstrated that the deposits at localities C, D, and E are of pre-Minooka age.

A. NW. ¼ sec. 21, Troy Twp. (T. 35 N., R. 9 E.). At this locality there is a total exposed thickness of slightly more than 4 feet of laminated, shaly-appearing, highly calcareous, bluish lake clay containing numerous small concretions. It appears in the north bank of the creek tributary to

Du Page River, and has a maximum elevation of about 565 feet. The uppermost foot of this clay is leached, that is, has lost its content of calcium carbonate, and so acids do not cause effervescence. It is underlain by Bloomington pink till, and overlain by yellow Minooka till.

B. NW. ¼ sec. 10, Troy Twp. (T. 35 N., R. 9 E.). A section in the west bank of Du Page River shows about 12 feet of Minooka till lying on some 4 feet of yellow silty sand which rests on one foot of smooth, blue, laminated clay, containing neither grains nor concretions. The bottom of the clay is not exposed. Its top is at an elevation of about 585 feet. The silty sand is very fine, without pebbles, is highly calcareous, and contains some clay which acts as a binder, making it very firm and compact. In places it appears thinly stratified. It also outcrops some 200 yards farther south.

C. NW. ¼ sec. 14, Joliet Twp. (T. 35 N., R. 10 E.). At the base of Knowlton Mound on East Washington Street, Joliet, the south bank of Hickory Creek shows a six-foot section of smooth, laminated, blue lake clays without pebbles, reaching to an elevation of about 564 feet. These are overlain by some 45 feet of glacial materials (fig. 34), largely conglomerate. The lake clays extend along the creek for more than 100 yards, and crop out in both banks.

D. SE. ¼ sec. 2, Joliet Twp. (T. 35 N., R. 10 E.). At Baer's sand pit, the exposed bank shows 18 feet or less of till uncomformably overlying about 14 feet of torrentially bedded sand (fig. 33) with pea-sized pebbles in it, resting on laminated sand of medium-grain more than 10 feet thick. The laminae are fairly thick and nearly horizontal. The top of these laminated lake sands is at an elevation of about 598 feet. They were exposed only in a test hole which was dug to determine the amount of sand available in the pit. This hole was but 10 feet deep, since it was limited by excess of ground water. This fact, together with the report that 200 yards to the east, 12 feet below the base of a pit, (elevation about 583 feet) a compact blue clay is encountered, indicates the possibility that the lake sands at Baer's pit are underlain by lake clays.

E. Sec. 19, Joliet Twp. (T. 35 N., R. 10 E.). The fifth locality where lake deposits are known to occur is at Joliet Mound. Years ago this was a flat-topped mound about ¼ of a mile long and 100 yards wide, with an area of slightly less than 9 acres, but the clay, sand, and gravel of which it was composed have been entirely removed. Flathead Mound in sec. 25, Troy Twp. (T. 35 N., R. 9 E.) although much larger, is now fast being removed by steam shovel, and at the present rate will soon be gone.

Bradley[1] is authority for most of the facts in the following description

[1] Bradley, Frank H., Geol. Survey of Illinois, Vol. IV, pp. 208, 222, 1870.

of Joliet Mound. The surface of the limestone at the base of the mound slopes downward to the west. Thus while at the east end of the mound there was a thickness of only about 20 feet of cemented gravels or conglomerate resting on a thin seam of blue clay above the rock, at the opposite end, the gravels had a thickness of 40-50 feet, and rested on a 7-foot bed of fine blue, pebbleless clay which Bradley says is of lake or river origin.[2] No lake clays have been seen below the gravel at Flathead Mound. Remnants of this blue clay at Flathead Mound were reported, but they were covered by slump gravels and other debris. It is impossible to tell what elevation this clay reached, but probably it was close to the 550-foot contour.

So far as now known, these lake deposits were made in local ponds, although there is some possibility they were deposited in large lakes. At no point within the Joliet quadrangle were beaches or other phenomena indicating a persistent shore line of a body of still water observed.

LAKE MORRIS

Lake Morris is the name Culver[3] has given to a glacial lake which formed some time after the Marseilles stage. It occupied the Morris Basin, a large shallow depression mainly in Grundy County southwest of the Joliet area, and beaches were formed along its shore at an elevation of about 560 feet. Its westward extension was limited by the Marseilles terminal moraine (fig. 26), but its eastern limits are unknown. Unless blocked by ice it covered all the area to the east below the 560-foot contour. It is possible that the clays at Joliet Mound in sec. 19, T. 35 N., R. 10 E. were laid down in Lake Morris, but the other lake deposits of the Joliet area are too high to have been formed in this lake.

LAKE ILLINOIS

Lake Illinois has been suggested by Dr. M. M. Leighton of the State Geological Survey for the name of a lake which perhaps existed with minor interruptions from the close of the Bloomington stage until Valparaiso times. It occupied much of the same area as Lake Morris, but was more extensive, and had a longer existence. Its western limit was the Bloomington terminal moraine (fig. 26), and its eastern shore is unknown, but perhaps it extended into the Joliet area. Culver found minor deposits of lake clays in the Morris quadrangle which may have formed in this lake, whose surface stood close to the 600-foot level. From the elevations of the lake deposits given in the preceding paragraphs, it is seen that all

[2] Leverett, Frank, The Illinois Glacial Lobe: U. S. Geol. Survey, Mon. 38, p. 377, 1899. Leverett presents a section measured as Joliet Mound with the statement that this clay is a still-water deposit.

[3] Culver, Harold E., Geology of the Morris quadrangle: Ill. State Geol. Survey Bull. 43B, p. 89, 1922.

of them except those at Joliet Mound are too high for the 560-foot level of Lake Morris, but that none of them are too high for the 600-foot level of Lake Illinois. No strong evidence of intermediate lake levels has thus far been found. It is possible that the first four lake deposits listed (p. 73) can be referred to Lake Illinois, but any such correlation would be highly speculative. If the lake clays at localities A, B, and C were deposited in Lake Illinois, the Early Wisconsin ice-sheet must have retreated beyond Joliet before the deposition of the Minooka and Rockdale moraines.

The deposit of lake sands at Baer's pit, (SE. ¼ sec. 2, T. 35 N., R. 10 E.) however, is noteworthy in that, although beaches are absent, the conditions of sedimentation are strong evidence in this matter. As already noted, this deposit consists of laminated sands, resting on unseen clays, but grading upward into torrentially-bedded sands containing small pebbles. Apparently the laminated sands were deposited in shallow water, gradually filling up this part of the lake, and as the conditions of sedimentation changed, the final product was river deposited sands. There is, however, no good section here that shows typical delta bedding, as might be expected under these conditions.

There are two localities, not previously mentioned, in the Joliet quadrangle where lake deposits of post-Bloomington and pre-Valparaiso age are perhaps present. In the creek valley in the SE. ¼ of sec. 9, Troy Twp. (T. 35 N., R. 9 E.), at several places a fine, silty, yellow, calcareous sand, locally laminated, is present beneath the clayey till. The elevation is about 580 feet, but the structure is not entirely typical of lake sands, and all the outcrops are very small. In an auger boring near the road on the south bank of Spring Creek in sec. 5, New Lenox Twp. (T. 35 N., R. 11 E.) below some 3½ feet of soil and leached clay a 4-foot section of finely-laminated blue clay was encountered overlying a fine gravel. This clay is possibly of lake origin. Its elevation is 625 feet.

MINOOKA DRIFT

Following the formation of the Bloomington moraine, the ice front retreated to the northeast, due to the melting and evaporation of the ice. Later, however, the ice front remained at a nearly constant position long enough for the Marseilles moraine (fig. 26) to be formed under its edge. Subsequently the ice front again retreated an unknown distance, but probably somewhat to the east of the Minooka till ridge, because, when this ridge was formed, the ice front had a new shape, as seen in figure 26. Equilibrium between ice advance and wastage was finally reached when the ice edge stood at the location of the Minooka ridge.

The "Minooka till ridge" (fig. 26) is the name given to the low ridge of drift, rarely more than 2 miles in width, extending almost due

south from Elgin to the head of Illinois River, a distance of 40 miles. The ridge is named from the village of Minooka situated on its summit about 3 miles south of the southwest corner of the Joliet quadrangle. The ridge seems to be cut off abruptly by Illinois River, at which it ends in a steep bluff more than 100 feet high. This bluff is obviously due to river erosion. How much farther the ridge once extended to the south or southeast is unknown.

While the name "Minooka till ridge" is one that can be considered as sanctioned, due to its common use in the glacial literature, it is a very minor topographic feature, and probably bears the least resemblance to a terminal moraine of any of the Wisconsin moraines in Illinois. There is little doubt but that the Minooka till ridge was deposited under the temporarily stationary edge of the ice and in that sense, is probably a terminal moraine. However, in literature, a terminal moraine has come to mean a body of drift that stands out as a distinct, ridge-like topographic feature, with a characteristic, more or less rough, "knob-and-kettle" type of topography. Kames (fig. 25E) and erratic boulders are generally abundant on a terminal moraine, which ordinarily has a linear continuity perhaps broken in places, but even here commonly connected by boulder belts. Furthermore, on its steeply sloping side, the side away from the direction in which the ice stood, it is bordered by an outwash plain (fig. 25), valley trains, or other fluvio-glacial phenomena. In this sense, the Minooka till ridge would therefore be regarded as a very weak and doubtful terminal moraine.

As shown in figure 26 and on Plate I, the main part of the ridge lies just west of the Joliet quadrangle, although it appears at the southwest and northwest corners, and also in one intermediate area. The thickness of the Minooka drift as given by well records for the Joliet quadrangle, as a rule, is between 60 and 70 feet. Leverett [4] states that the thickness of the till in the ridge is between 130 and 150 feet. None of the wells on the Joliet quadrangle are on the crest of the ridge.

The ridge has gentle slopes, noticeably steeper on the west than on the east, and has a topography much too smooth for a typical terminal moraine. Only rarely are shallow undrained depressions seen. Its highest point on the Joliet quadrangle is slightly above the 720-foot contour. On approaching it from the east, a rise can be seen ahead by the careful observer, but unless watched for, the crest is reached without realizing it. In fact, it is so ill-defined that its boundaries cannot be exactly located on a map, except in a few places.

East of the Minooka till ridge, extending nearly half way across the Joliet map at the surface, and having an unknown continuation farther

[4] Leverett, Frank, The Illinois Glacial Lobe: U. S. Geol. Survey Mon. 38, p. 320, 1899.

to the east below later deposits (sections A-A and B-B, Plate I), lies the main mass of the Minooka drift. It was largely formed as a deposit under the body of the ice while the Minooka till ridge was being formed under its edge. It has a thickness ranging up to 65 feet or slightly more. In general its surface is essentially flat (figure 28), except where eroded by streams.

The Minooka drift, like most of the younger drift in the quadrangle, is remarkably free from pebbles and stones. The fresh drift consists mainly of bluish calcareous clay which is generally gritty, but locally as at the old clay pits south of Plainfield, is almost as free from stones as are lake clays. For an average depth of from 3 to 4 feet it is entirely leached of calcareous matter although in valley bottoms this depth is greater, and

Fig. 28. Minooka ground moraine showing its flat surface. View taken from a point ½ mile northeast of Caton Farm, sec. 29, Plainfield Township (T. 36 N., R. 9 E.), looking west towards the Minooka till ridge in the distance.

on slopes it is less. It is yellow at the surface, and to depths of 10 feet or more, resulting from the oxidation and hydration of the iron. Like the other Late-Wisconsin drift sheets, the Minooka drift is covered in most places by a layer of clayey loam, which, although it varies greatly, probably averages less than one foot in thickness. This loamy cover which is non-calcareous, probably was formed by the wind after the retreat of the ice, before the development of a marked growth of vegetation, or by earthworms and ants which worked up finer material from below. Rare pebbles are found in it which were probably brought up by burrowing animals or by the upturning of trees. Good sections of Minooka till may be seen along the west bank of Du Page River in the west-central part of Plainfield Township (secs. 20 and 28, T. 36 N., R. 9 E.) and near the south edge

of the map. There are other excellent exposures on the east side of Lilly Cache Creek in the NW. part of section 26, Plainfield Township, and along the creeks in section 17, Plainfield Township and in section 9, Troy Township (T. 35 N., R. 9 E.).

KAMES AND ESKERS

An esker is a ridge of poorly stratified sand and gravel, which probably in most cases originated by deposition from an overloaded stream flowing under the ice-sheet (fig. 25G). Kames are knolls or hillocks of poorly assorted sand and gravel which sometimes may be rather ridge-like, and resemble eskers (fig. 25E). Two eskers are mapped (Pl. I), both on the Minooka drift sheet. The Wheatland esker is in the northern part of section 19, Wheatland Township (T. 37 N., R. 9 E.) and is more or less intermediate in form between a kame and an esker. It extends 200 yards west of the quadrangle boundary, and the whole interior of it has been excavated for gravel. It stands up as a prominent ridge if viewed from the road to the north, but has a gentle slope towards the south. For a typical esker, its breadth as compared to its length is rather too great. The Naperville esker is in sections 26 and 27, Naperville Township (T. 38 N., R. 9 E.) and shows more of the esker characteristics, although it is a very low ridge, only slightly developed. It is about a mile long, rarely 100 yards in width and is broken into five parts. Several gravel pits are located in it. Heterogeneous, ill-assorted gravel is more or less characteristic.

Kames are mapped on all the drift sheets, but there is no excellent example of a kame in the region. Of the seven mapped, three are on the Minooka drift (Pl. I). Some of the pebbles in kames are striated and are commonly angular and coated with silty material, indicating that they were deposited by muddy waters. Kames are believed to have originated by deposition from overloaded streams where they issued from cracks or re-entrants in the ice, as illustrated diagrammatically in figure 25. The sudden checking of a swift-flowing, debris-bearing stream as it flows out from the ice would cause a rapid dropping of its load. Better examples of kames and eskers than are seen in the Joliet quadrangle are mapped by Trowbridge[5] in the Wheaton area immediately adjoining on the north.

JOLIET OUTWASH PLAIN

Following the deposition of the Minooka drift, there was an extensive retreat of the edge of the ice-sheet to the northeast. As it withdrew, and later, while it again advanced after a possible stationary interval of unknown duration, the waters that flowed from the melting ice carried with them much debris from the glacier and by the deposition of this material, an extensive

[5] Trowbridge, A. C., Geology and geography of the Wheaton quadrangle: Ill. State Geol. Survey Bull. 19, pp. 50-59, 1912.

plain composed of sand and gravel was formed in front of the ice. Such a plain is called an "outwash plain." The thickness of the deposit varied, due largely to inequalities of the surface on which it was laid down, but also to variations in supply of material at different places. The tendency was toward the formation of a fairly smooth sheet of gravel sloping gently downward to the west away from the ice edge, furrowed by channels of varying sizes. That the ice retreated an unknown but considerable distance to the east after the deposition of the Minooka till is shown by the existence of an extensive bed of gravel, locally absent, locally firmly cemented into a conglomerate, and in places as much as 50 feet thick, lying on bed rock or on till of Minooka age or older, and, where buried, covered by till of Rockdale

Fig. 29. View of Iper's gravel pit, section 2, Du Page Township (T. 37 N., R. 10 E.) showing coarse gravel overlain unconformably by Valparaiso till.

or Valparaiso age, extending miles east of Des Plaines River. The name "Joliet outwash plain" will be used in referring to this inter-till outwash sheet.

For a general diagrammatic picture of this gravel sheet, the reader is referred to Plate I showing east-west sections across the Joliet quadrangle. That the area covered by the gravel is extensive is shown by the fact that it appears in sections from the north to the south edges of the quadrangle. Thus gravel very apparently underlies Valparaiso till near the north edge of the quadrangle along the east and south sides of East Branch of Du Page River (fig. 29). It also underlies this till along the southeast side of Des Plaines River as shown in the bluffs from 1 to 3 miles west of Lemont

(fig. 30). The same relation is apparent at Romeo (fig. 31), and to the south as far as the north edge of Lockport, where the gravel underlies both the Valparaiso and the Rockdale tills. In the bluffs extending from the steel

Fig. 30. Conglomerate (at right) and cross-bedded sands overlain by Valparaiso till, 1½ miles west of Lemont (NW. ¼ sec. 30, Lemont Township, T. 37 N., R. 11 E.).

mills southeast along the northeast side of Joliet, the gravel sheet, which is largely cemented into a firm conglomerate (fig. 32), can be traced almost continuously, nearly everywhere underlying till. From this point for a mile

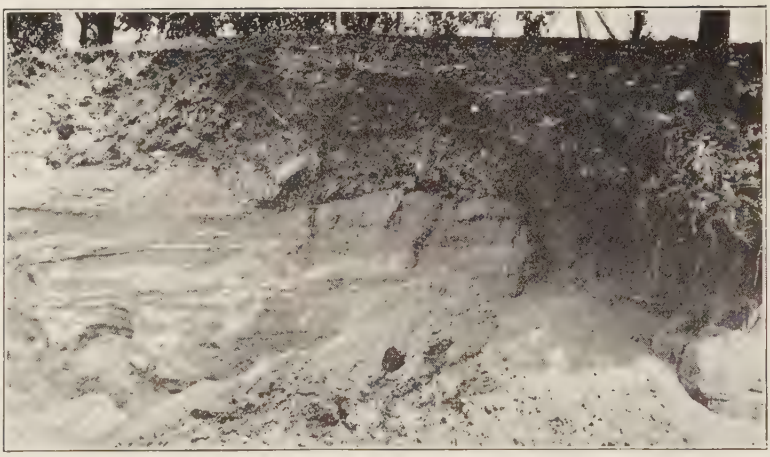


Fig. 31. Section at Romeo sand pit showing cross-bedded, pebbly sands overlain by stony till of Valparaiso age. Note the irregularity of the contact.

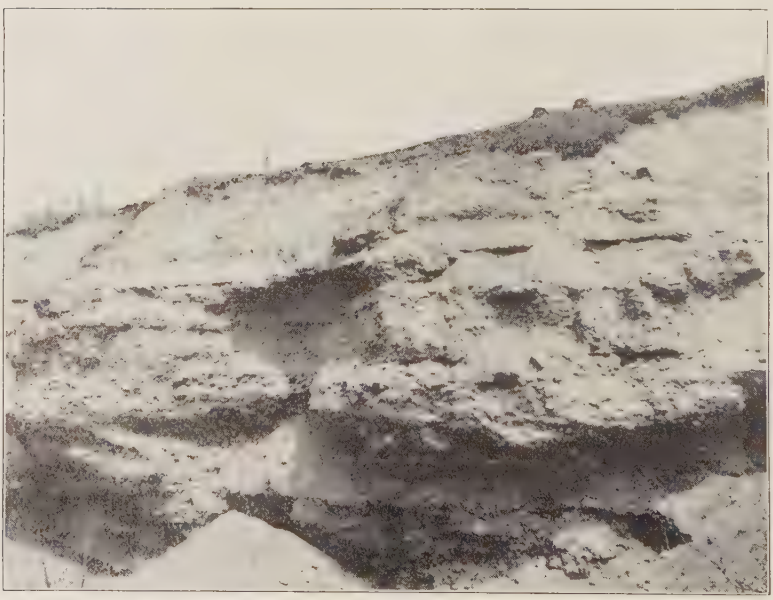


Fig 32. Exposure of conglomerate belonging to the Joliet outwash plain near Spring Creek, T. 35 N., R. 10 E., overlain by Rockdale till.

up Spring Creek, on both sides of the valley, sands and gravels are seen underlying till (fig. 33). This relationship is also seen on the southeast side of Joliet in the bluffs extending from Elmhurst Cemetery southwest as far as Rowell Avenue. Again at Bennett's sand pit in section 24, Troy Township (T. 35 N., R. 9 E.), an excellent section of stream-deposited sands underlies the Rockdale drift sheet.

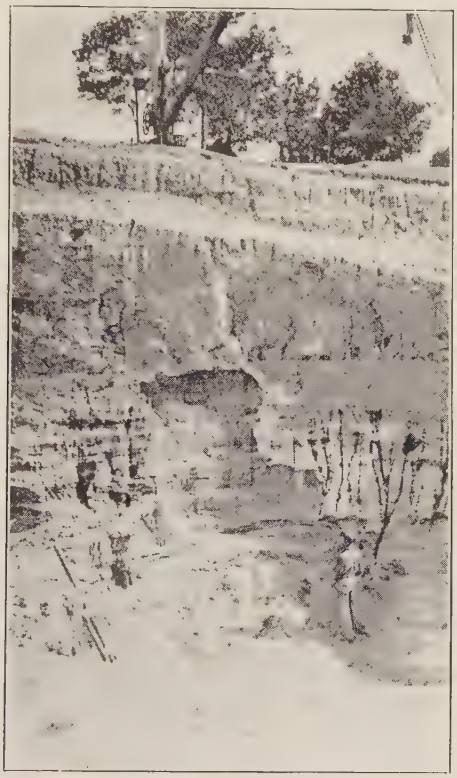


Fig. 33. Baer's sand pit, SE. ¼ section 2, Joliet Township (T. 35 N., R. 10 E.) showing Rockdale till resting unconformably on cross-bedded, pebbly sands. Laminated lake sands and silts lie below the feet of the man.

On the Des Plaines quadrangle near the village of New Lenox in the SW. ¼ of the NW. ¼ of section 16, T. 35 N., R. 11 E., more than 10 miles east of the nearest outcropping Minooka drift, a gravel pit cut in the north bank of Hickory Creek shows 6 to 10 feet of till overlying a section of gravels at least 15 feet in thickness. On the Wheaton quadrangle near

Naperville in the SW. ¼ of section 18, T. 38 N., R. 10 E. the section exposed in Ritzert's gravel pit shows 6 feet of Valparaiso till over 25 feet of gravel resting on Minooka till. Gullying of the neighboring area indicates that the gravel sheet has a nearly horizontal surface, since the gravel outcrops in these gullies like a horizontal rock stratum.

Well records confirm the widespread occurrence of this sheet of gravel. In this connection it is interesting to note that Leverett[6] also found evidence from wells that sand and gravel underlie the Valparaiso till in many places. He also mentions that there is in places a heavy deposit of sand beneath the Minooka till. With one or two rare and unimportant exceptions, no wells were found in the Joliet quadrangle which showed sand or gravel below the Minooka drift. Moreover, along the west bank of Du Page River, at the big bend south of Plainfield and also near the southern edge of the quadrangle, the Minooka drift has been undercut by the river, exposing it in bluffs. Such exposures are ideal for verifying the presence or absence of a gravel sheet, such as is postulated, especially where the drift rests on bed rock as it does near the southern boundary of the quadrangle. However, careful search failed to reveal any evidence of such a sheet.

From the evidence presented, the conclusion is reached that following the Minooka epoch, an extensive sand and gravel outwash plain was formed by debris-laden waters pouring out from a melting ice sheet. Figures 29 to 33 show the gravel below the till at widespread localities. It is not certain, however, that the gravel and conglomerate shown in all these figures are of pre-Rockdale age. It is believed that further work in neighboring areas to the north, east, and south will bring to light more sections showing this relationship and perhaps fix the size of the area covered by this buried Joliet outwash plain.

All sand and gravel and sandstone and conglomerate formed from the sand and gravel of the drift are designated on the map (Pl. I) by the same symbol. This does not mean that it is all of the same age, but rather that it is considered impossible to distinguish in most cases between outwash of different ages in this region, and that it is deemed impracticable to attempt to map the conglomerate distinct from the gravel. All this material has had the same origin, namely deposition from waters formed by the melting of the ice.

Sandstone and conglomerate formed by the local cementation of these outwash sands and gravels are widespread, and are especially common along Des Plaines River. They were observed on both sides of this river, and intermittently for its whole length across the Joliet sheet. However, they are not limited to the neighborhood of Des Plaines River, for conglomerate

[6] Leverett, Frank, The Illinois Glacial Lobe: U. S. Geol. Survey Mon. 38, pp. 321 and 649, 1899.

is found on the east bank of Du Page River in section 14, Wheatland Township (T. 37 N., R. 9 E.), just north of the road, and sandstone is present in the valley of the creek tributary to Rock Run in the SE. ¼ of section 11, Troy Township (T. 35 N., R. 9 E.). On the basis of this widespread distribution of sandstone and conglomerate, and since in all occurrences the limits of the cemented areas are notoriously irregular in all directions, the cementation is considered to be dependent upon purely local ground water conditions, and to be of no value as a criterion for differentiating glacial outwash of one age from that of another. Figures 32 and 34 show cemented outwash material. In all cases observed, the cementing material of the

Fig. 34. Conglomerate exposed on the south bank of Hickory Creek at Knowlton Mound, NW. ¼ of section 14, Joliet Township (T. 35 N., R. 10 E.). Blue, laminated, lake clays appear in the section in the lower right hand corner near the water.

sandstone and conglomerate is calcium carbonate, though this is often iron-stained. Goldthwait[7] mentions one locality where the cement is iron hydroxide (limonite).

Localities where the cemented outwash may be well seen include the section in the southeast wall of Des Plaines Valley one to three miles west of Lemont as shown in figure 30; in the east wall of Des Plaines Valley just north of Lockport (section 14, T. 36 N., R. 10 E.); in the low bluff just north of Spring Creek in section 2, T. 35 N., R. 10 E. (fig. 32) where it joins Des Plaines Valley; at Knowlton Mound on the south side of Hick-

[7] Goldthwait, J. W., Physical features of the Des Plaines Valley: Ill. State Geol. Survey Bull. 11, p. 42, 1909.

ory Creek on East Washington Street, Joliet in the NW. ¼ sec. 14, T. 35 N., R. 10 E. (fig. 34); in the bed of the creek (fig. 35) just above Bush Park (West Park), near Joliet, where it underlies Rockdale drift; and in the walls of this creek some 300 feet farther east where it is apparently underlain and overlain by till. On the southeast bank of the stream, at the bend between those two places, uncemented gravels appear, overlain by till.

Fig. 35. Conglomerate belonging to the Joliet outwash plain overlain by Rockdale till. Creek bed in Reed's woods just above Bush Park in the cen. NE. ¼ SW. ¼ sec. 17, T. 35 N., R. 10 E.

At Flathead Mound, about 3 miles southwest of Joliet, in section 25, T. 35 N., R. 9 E., both gravel and conglomerate are exposed.

It is interesting to speculate on the relation of the Joliet outwash sheet to the hypothetical Lake Illinois previously mentioned. It seems possible that this lake was in existence when the gravel sheet was being formed,

but its limits are not known. Certainly the outwash material referable to the Joliet outwash sheet which is seen in Baer's sand pit overlying laminated sands of lake origin and underlying Rockdale drift (fig. 33), would point to the essential contemporaneity of Lake Illinois and the Joliet outwash sheet, assuming that the theoretical explanation of the lake sands is correct. (p. 76.)

ROCKDALE DRIFT

Following the formation of the Joliet outwash plain, the edge of the ice sheet advanced again, moving westward until it occupied a nearly north-south position running across the Joliet quadrangle slightly east of Du Page River. That it held this position for some time is evinced by the fact that the Joliet outwash gravels are covered by 50 feet or more of till deposited by the ice of this epoch. This body of drift, called Rockdale drift in this bulletin, is named from the village of Rockdale some two miles southwest of Joliet. It appears as a steep till bluff to the north of the village.

Near the north edge of the Joliet quadrangle, the Rockdale drift is overlapped by the younger Valparaiso moraine, and is unknown farther north. The extension of the Rockdale drift to the south and southeast is indicated on figure 26. Detailed work will perhaps result in the correlation of this drift with Leverett's Kalamazoo moraine[8] of Indiana and Michigan. Leverett considers that the Kalamazoo morainic system has not been identified with certainty farther west than Warren, Indiana, but his map indicates that the system may continue westward into Illinois and, if it does, it would possibly be correlated with the Rockdale drift of the Joliet area. However, any possible correlation is purely tentative as yet, and must be substantiated or disproved by later detailed field work. In Michigan, the Kalamazoo is the moraine next older than the Valparaiso, as is the Rockdale in the Joliet quadrangle.

On the whole, the Rockdale till sheet, especially in the southern part of the quadrangle, is less smooth than the Minooka drift. Gentle swells with low hillocks and shallow saucer-like undrained depressions are common, and in places there is a slight hint of the "knob-and-kettle" type of topography that is typical of a terminal moraine. The highest point on this drift sheet within the quadrangle is slightly less than 700 feet.

In constitution, the Rockdale till does not noticeably differ from the Minooka. Both are relatively pure clay, comparatively free from stones larger than small grains, considering their origin under an ice-sheet. Both are leached of calcium carbonate and show oxidation of iron to about the same depth. In fact the distinction between the two is based solely on

[8] Leverett, Frank, The Pleistocene of Indiana and Michigan: U. S. Geol. Survey Mon. 53, pp. 174-175 and Pl. 32, 1915.

stratigraphic and geographic grounds, as even the topography of the two is not distinctive. In general, the Rockdale drift overlies the Joliet Gravel Plain. Where this gravel sheet is absent, the Rockdale till presumably rests directly on the Minooka drift, or on the Silurian dolomite.

Two kames are mapped (Pl. I) on the Rockdale drift, one in section 2, T. 35 N., R. 10 E. and one in section 18, T. 35 N., R. 11 E. Good sections of Rockdale drift may be seen along the northeast, east, and southeast sides of Joliet, as well as along the lower courses of Spring and Hickory Creeks (T. 35 N., R. 10 E.) east of the wall of the large valley now occupied by Des Plaines River (Pl. I). A fine section is exposed at the abandoned gravel pit in the north-central part of the SW. ¼ of section 12, Joliet Township (T. 35 N., R. 10 E.), where a 3-inch soil layer grades down into a 10-inch layer of yellowish, non-calcareous clayey loam without pebbles which overlies 2 feet of buff-yellow till that has lost its calcium carbonate by the leaching action of percolating water. This leached till rests on calcareous yellow till, but the contact between the two is a narrow zone rather than a plane surface. Other good cuts in the Rockdale till may be seen along the creek just north of Lockport, in sec. 14, T. 36 N., R. 10 E.; along the east side of Rock Run in the SE. ¼ of section 11 and the NE. ¼ of section 14, Troy Township (T. 35 N., R. 9 E.); and in the bluffs north of Rockdale, especially along the creek in Reed's Woods in the NW. ¼ SW. ¼ sec. 17, T. 35 N., R. 10 E.

As the ice which deposited the Rockdale drift retreated slightly from its line of maximum advance, and perhaps when it was at this line, it seems that most of its drainage in the Joliet quadrangle was confined to the four or five main channels shown on Plate II. In these channels valley trains were developed. One of these drainage lines was along the site of the present Des Plaines valley near Rockdale; another through Rock Run slough (southwest part of Lockport Township); a third along Mink Creek slough (northwest part of Lockport Township); a fourth through Lilly Cache slough (southwest part of Du Page Township); and a possible fifth along East Branch of Du Page River (northern part of Du Page Township). These possible channels were not then pronounced valleys or sloughs as they are now, but probably were slight depressions, most of them due to irregularities in the thickness of the drift sheet. The valley in which Des Plaines River now crosses the quadrangle was then a rock valley, but it was no doubt largely filled with glacial debris and its site was probably marked by a relatively slight valley in the till. The discrepancies between the surface of the drift sheet and the underlying rock surface are shown in the cross-sections on Plate I. Thus 2 miles west of the eastern end of section A-A, there is a notable depression (shown in two dimensions) in the bed rock with a high till surface above.

These valleys resembled only slightly the present sloughs. They probably had channels, the floors of which were all of nearly the same elevation, an elevation higher than any of the present slough bottoms. The present sloughs had their beginning at this time, and have been valleys ever since, although with little doubt they all owe their present depth to later erosion in connection with the outflowing waters from the lake which was the ancestor of Lake Michigan.

VALPARAISO DRIFT

How far the ice-edge retreated to the east or northeast after the formation of the Rockdale drift has not been determined. That it retreated beyond the present outer limit of the Valparaiso moraine seems well substantiated, as the Valparaiso ice-edge overlapped the Rockdale drift north of the East Branch of Du Page River, showing that there was a sufficient retreat of the ice to allow it to reform into a lobe of somewhat different shape.[9]

The Valparaiso morainic system consists of several minor moraines, and is the most pronounced body of morainic material of Late Wisconsin age in Illinois. It extends in a broad belt generally some 10 miles wide and parallel to the shore of Lake Michigan from Wisconsin on the north through Illinois and eastward into Indiana and Michigan. Its size and relations in Illinois are shown in figure 26. Its outer edge runs about south-southeast across the northeastern part of the Joliet quadrangle, extending from West Branch of Du Page River along a line running just east of Lockport, and off the map near the southeast corner.

The thickness of the Valparaiso drift on the Joliet quadrangle is both greater and more variable than that of any other drift sheet. This is due to the facts that the bed rock surface has its greatest relief in the eastern part of the quadrangle, and that the ice of the Valparaiso stage probably was more active and lasted longer than that of the Rockdale or the Minooka stages. The bed rock surface contour map (Pl. II) shows an area along the eastern edge of the quadrangle away from the present large valleys, where, in less than 4 miles, the rock surface has a relief of more than 140 feet. In the same region the drift varies in thickness from 110 to 160

[9] Recent work by Mr. Ekblaw and the writer indicates that following the Rockdale, but preceding the Valparaiso, the ice maintained a more or less stationary edge long enough to build a minor moraine which may be designated the *Manhattan ridge*, since it is well developed near the village of Manhattan about 8 miles southeast of Joliet. Its outline is tentatively indicated on figure 26. It is not clearly differentiated on the Joliet quadrangle, but it is possible that it coalesces with the Rockdale moraine along the west side of Joliet following a line up the valley of the creek in Bush Park (southern half of section 17, Joliet Twp.) and thence northeast diagonally through section 8. To the southeast it appears to again coalesce with the Rockdale moraine just north of Momence; and so it may represent a sub-stage during the retreat of the Rockdale ice-sheet.

feet, which shows how little the present surface conforms to the pre-glacial surface. At an intermediate point in the valley of Spring Creek the thickness of the drift is only 70 feet, but this is probably due largely to subsequent erosion of a thicker body of drift. At no point on the Joliet quadrangle is the thickness of the drift known to be greater than 160 feet. It is possible or even probable that all of this thickness is not Valparaiso drift. A part of it may be older. Leverett[10] cites a well just south of Barrington 42 miles north of Joliet which shows that the drift within the limits of the Valparaiso moraine is more than 315 feet thick, but he estimates that the average thickness of this drift sheet is less than 65 feet.

The topography of the Valparaiso moraine is more characteristic of terminal moraines than any other part of the drift in the quadrangle. In the valley of Long Run in NW. ¼ sec. 6, T. 36 N., R. 11 E., there is a small area which illustrates the "knob-and-kettle" topography that best characterizes the Late Wisconsin terminal moraines (fig. 36, A and B). In addition the topography locally approaches that of a typical terminal moraine near the east edge and the northeast corner of the quadrangle but the most pronounced "knob-and-kettle" topography, lies north of the Joliet quadrangle. Such topography is well known in the Wheaton quadrangle[11] near West Chicago, and in the Barrington quadrangle[12] near Fox River Grove.

The Valparaiso moraine in the Joliet quadrangle does not show a marked difference in constitution from that of the Minooka and the Rockdale till sheets, previously described. It is differentiated from these mainly by topography, stratigraphy, and distribution. No eskers were noted on it, but kames were observed in the area between the two branches of Du Page River in T. 38 N., R. 10 E. (Pl. I). Good sections of Valparaiso till may be seen along Long Run, in the bluffs on both sides of Des Plaines River southwest of Lemont, and along the east and south sides of East Branch of Du Page River. There is an area of drift, containing large amounts of gravel, which lies mainly in secs. 27, 28, and 29 of Du Page Township (T. 37 N., R. 10 E.) west of the Valparaiso moraine, mapped on Plate I as of Rockdale age. It is possible that this may be, at least in part, outwash from the Valparaiso ice-sheet, though the area lacks the topography of a typical outwash plain.

PLAINFIELD GRAVEL PLAIN

It seems probable that while the Valparaiso moraine was being formed under the edge of the ice-sheet, gravel and sand washed out from the melt-

[10] Leverett, Frank, The Illinois Glacial Lobe: U. S. Geol. Survey Mon. 38, p. 354, 1899.

[11] Trowbridge, A. C., Geology and geography of the Wheaton quadrangle: Ill. State Geol. Survey Bull. 19, 1912.

[12] MacClintock, Paul, The Geology of the Barrington quadrangle: Ill. State Geol. Survey Bulletin in course of preparation.

ing ice were being deposited along the outlet valleys and in the area about Plainfield. The plain area near the village is known as the "Plainfield gravel plain." Figure 37 is a diagrammatic stereogram which gives some

A

B

Fig. A and B. Topography of the Valparaiso terminal moraine in the valley of Long Run. (NW. ¼ of sec. 6, T. 36 N., R. 11 E.).

idea of the glacio-fluvial processes taking place at this time according to this conception. Note that streams occupied Lilly Cache, Mink Creek, and Rock Run sloughs. The bottoms of the sloughs and Des Plaines Valley

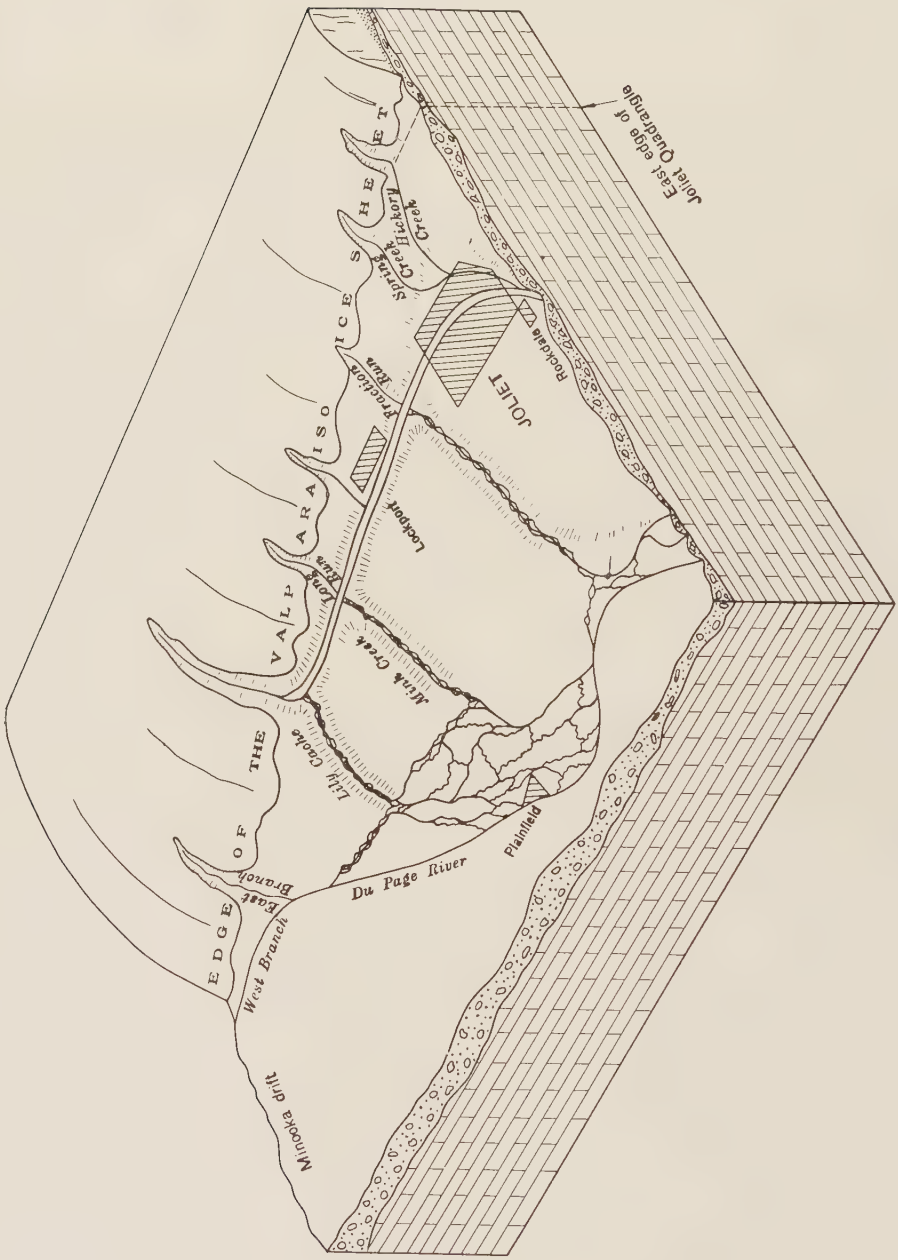


Fig. 37. Stereogram showing conditions during the Valparaiso stage

were not so deep as now, and were all at about the same level. Des Plaines Valley was largely filled with debris from the ice-sheet. It seems probable that overloaded braided and branching streams covered the area east of Plainfield, as indicated on the stereogram. Braiding and branching is explained by the fact that deposition results wherever a stream has a larger load than it can carry. This is commonly the case of streams formed by a melting ice-sheet. This often causes the stream to give off distributaries, since deposition tends to fill the main channel until it is too small to accommodate all the water, which then overflows the banks of the channel at various points. At this time the Plainfield gravel plain, except that part of it that may be referred to the Joliet outwash plain or to outwash

Fig. 38. Lake Renwick, showing a section of the Plainfield gravel plain. (Sec. 15, T. 36 N., R. 9 E.)

from the ice of the Rockdale epoch, was formed. Figure 38 shows a section of the materials composing the Plainfield gravel plain, and figure 39 its flat surface.

Figure 40 shows a section of gravel with the overlying brown loam characteristic of the region. The loam in this section consists of about a foot of non-calcareous clayey earth which grades up into soil and down into gravel, the uppermost 6 inches of which is leached. The thickness of this brown loamy zone is extremely variable, but it is rarely greater than 3 feet, and sometimes only an inch or two. As can be seen from the photograph, the contact with the underlying gravel is noticeably undulating, due in part to the unequal depth of leaching. Rarely small pebbles are seen in

the clayey zone, but these were possibly brought up from the underlying gravel by burrowing animals or the upturning of trees. This surface clay is similar to the leached upper part of the loess over some of the older

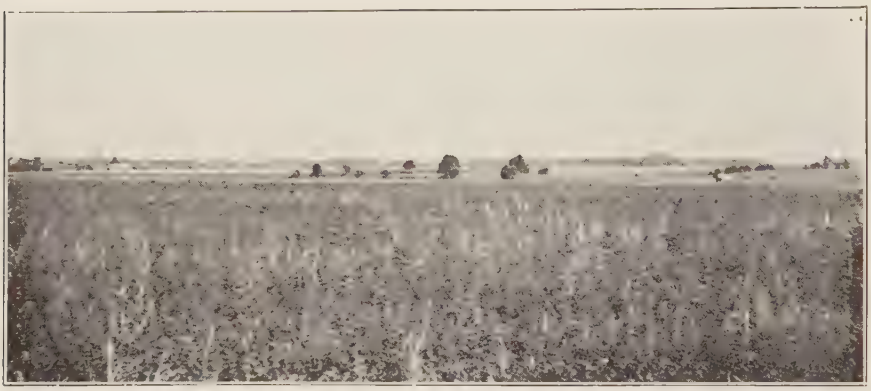


Fig. 39. Topography of the Plainfield gravel plain. The surface is fairly level, but shows shallow channels which are rather broad (center of sec. 21, Plainfield Twp., T. 36 N., R. 9 E., looking northeast).

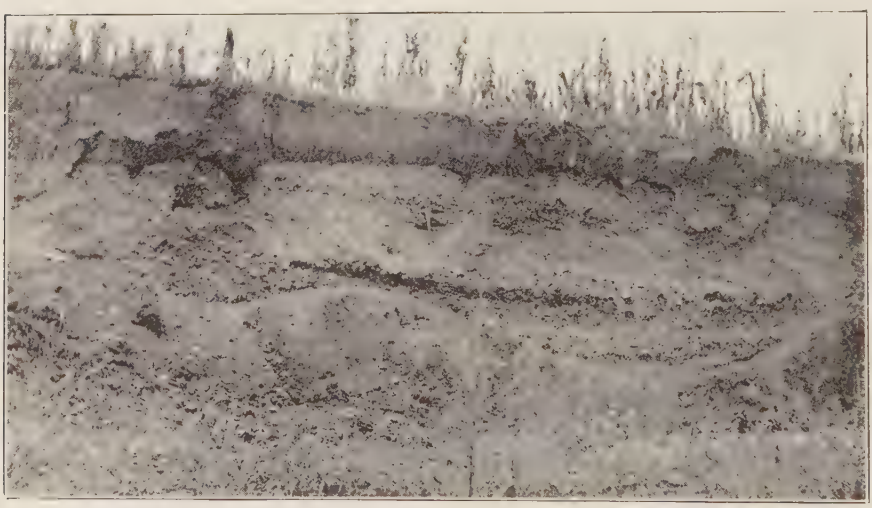


Fig. 40. Detailed gravel section, showing overlying brown loamy zone. (Gravel pit on the southwest side of the Lincoln Highway in sec. 23, Plainfield Twp., T. 36 N., R. 9 E.)

drift sheets in Illinois. It is also similar to the loamy cover over most alluvial flood-plain deposits. It probably originated as a deposit from some

of the last waters that flowed over the gravelly areas, when they carried only fine silts.

CHANGES DUE TO GLACIATION

After the deposition of a considerable body of drift under the edge of the Valparaiso ice-sheet, the ice-edge gradually retreated to the northeast beyond the limits of the Joliet quadrangle. However, waters from the melting ice still flowed across the quadrangle, and had a marked effect on its subsquent history.

Before discussing the effect of this outflow, we may contrast the present surface of the area with the surface which existed before the coming of the last ice-sheet.

Intermittently, for a period extending over perhaps a million years, the Joliet area was alternately covered by and free from large ice-sheets. The ice was many hundreds, perhaps a few thousands of feet in thickness. The exact thickness is unknown, and was no doubt widely variable with the different ice-sheets, but in the Adirondack Mountains of northern New York, the nearest considerable mountains covered by an ice-sheet, the glacier overrode the highest peaks more than a mile above sea-level and more than 3000 feet above their immediate surroundings. That such immense bodies of ice in motion would have a pronounced effect on the surface over which they passed is apparent. The general changes effected in this area have been described earlier in this chapter.

Drainage was completely interrupted in the area covered by the ice. The valleys were more or less filled with glacial debris, so that after the ice retreated the streams in many cases did not resume their former courses, but chose new channels, many of which bore no definite relation to the earlier valleys in the underlying rock. The changes of this nature effected in this area by the earlier glaciations have not been completely deciphered, and probably never will be. But it is possible to form a fairly accurate conception of the changes of this sort caused by the last ice-sheet that covered the area, compared with the conditions which existed when the drainage of the area was distinctly related to the bed rock surface.

The contour map (Pl. II) showing the bed rock surface reveals several rock valleys, of which that now occupied by Des Plaines River is the most pronounced. Du Page River and Rock Run occupy small rock valleys near the southern edge of the quadrangle, but these are of relatively recent origin. Elsewhere Du Page River does not occupy a rock valley of importance, except East Branch, which occupies a drift valley superimposed on a rock valley. There are slight indications that this rock valley sloped downward to the north, whereas the present Du Page Valley slopes to the south. Field study indicates that this part of Du Page Valley resulted from

the failure of the drift to fill the rock valley beneath. The presence of undrained depressions of morainic type on the slopes of this valley as low down as 700 feet, almost 100 feet below the top of the neighboring moraine as seen in the north-central part of section 34, Lisle Township (T. 38 N., R. 10 E.), proves this was a valley in the surface of the drift. This valley was occupied by East Branch, which has since deepened it.

Lilly Cache (T. 37 N., R. 10 E.) and Mink Creek (T. 36 N., R. 10 E.) sloughs are unrelated to rock valleys; in fact, a shallow rock valley appears to cross their courses diagonally northeast-southwest. Rock Run slough, the most southerly of the three sloughs (T. 36 N., R. 10 E.), is a valley in drift over a rock valley, but its bottom is cut down nearly to the surface of the bed rock. A great volume of water probably poured through this slough at one time, and removed any morainal characteristics that its walls may once have had. The well records at the New Penitentiary (Nos. 239 and 240, Table 9) prove that the rock valley is much wider than the slough at its eastern end. That the old rock valley was once largely filled with drift is shown by the fact that this drift has not been removed in the area near the New Penitentiary. This proves that this rock valley existed before the ice of the Rockdale stage covered the area.

With the exception of the rock valley beneath East Branch of Du Page River, all known rock valleys in the quadrangle seem to indicate that the latest drainage in the area which was distinctly related to the bed rock surface, was to the south or southwest as it is now. That the old rock valley now occupied by the diminutive DesPlaines River was a rock valley before the Late Wisconsin sub-epoch is strongly indicated by the finding of clays of lacustrine origin in the base of the valley near Joliet (p. 74). The finding of glacial striae on the bed rock surface in the bottom of the valley near Lemont, proves that the rock valley existed when the ice sheet which made the grooves covered the area. These striae (fig. 23) can be observed in the bed of a ravine in the south-central part of section 17, Downer's Grove Township (T. 37 N., R. 11 E.), on the west side of the road just across from the house shown on the map (Pl. I). The map shows an arrow, which indicates the bearing of these striae, S. 55° W. Leverett[13] has described glacial striae from the bottom of the rock valley near Lemont, as well as striae at Joliet near the old penitentiary with a bearing of S. 96° W. Such striae are not to be confused with the grooves seen in the channels in the bed rock at the quarry of the National Stone Co. (SE. ¼ sec. 21, Joliet Twp.), described on page 56.

The glacial striae are at an elevation of about 610 feet. The lake clays near Joliet are found at a lower elevation, certainly as low as 560 feet, and

[13] Leverett, Frank, The Illinois Glacial Lobe: U. S. Geol. Survey Mon. 38, pp. 413 and 416, 1899.

probably as low as 540 feet at Joliet Mound. This indicates that this valley was occupied, presumably in pre-Wisconsin times, by a river flowing to the south or southwest. This old rock valley continues across the northwest part of the Wilmington quadrangle, underlying the Minooka till ridge. Culver[11] maps a buried rock valley in the Morris quadrangle which may be the continuation of this large rock valley. Sauer[15] mentions the presence of a buried channel south of Morris, and an abandoned channel east of Ottawa. Cady[16] maps a buried valley just south of the present Illinois valley on the La Salle and Hennepin quadrangles, and Leverett[17] has recently presented evidence to show that the pre-glacial Mississippi River flowed from a point north of Rock Island southeast and joined the present Illinois valley near Hennepin. Thus it seems that the rock valley now partly occupied by Des Plaines and Illinois rivers was the site of an older (probably pre-Wisconsin and possibly pre-Illinoian) river which may have been tributary to the pre-Illinoian Mississippi River near Hennepin.[18]

If this interpretation is correct, the drainage changes effected by the last ice-sheet that covered the Joliet quadrangle are not of major importance. Minor drainage changes are numerous. Fraction Run (T. 36 N., R. 10 E.) is an example of a stream that has excavated a small gorge since the retreat of the ice-sheet. Most of the other streams are in valleys unrelated to rock valleys, although Hickory Creek (T. 35 N., R. 10 E.) may be an exception in the lower part of its course. Long Run (T. 36 N., R. 10 E.) is a conspicuous example of this minor lack of harmony between the rock surface and the present valleys. Other cases may be seen from a study of Plate II.

The ice-sheet effected changes in topography other than those which changed the drainage. The maximum relief of the bed rock surface for the quadrangle is about 170 feet, whereas that of the drift surface is nearly 300 feet. Glaciation has probably tended to make the surface of the quadrangle rougher, though this is far from certain. It has masked certain pronounced irregularities in the bed rock surface, notably the large depression in section 5, New Lenox Township (T. 35 N., R. 11 E.). Whether this depression was undrained, or had an outlet to the east is not determined. Its existence is well substantiated by several well records. On the whole the bed rock surface contour map, Plate II (and the structure sections, Plate I) best

[14] Culver, Harold E., Geology of the Morris quadrangle: Ill. State Geol. Survey Bull. 43B, fig. 33, 1922.

[15] Sauer, C. O., Geography of the Upper Illinois Valley: Ill. State Geol. Survey Bull. 27, pp. 96 and 128, 1916.

[16] Cady, G. H., Geology of the Hennepin and La Salle quadrangles: Ill. State Geol. Survey Bull. 37, p. 96, 1919.

[17] Leverett, Frank, Outline of Pleistocene history of the Mississippi Valley: Journal of Geology, Vol. XXIX, pp. 615-626, 1921.

[18] For more data on the pre-glacial Great Lakes drainage see Leverett and Taylor, Pleistocene of Michigan and Indiana, U. S. Geol. Survey Mon. 53, pp. 316-318, 1915.

bring out the contrast between the bed rock and the till surfaces. How much the topography of the bed rock shown on the contour map is due to abrasive action of the ice-sheet is difficult to say. It seems probable that it is not fundamentally different from what it was in pre-Wisconsin times when it was presumably mantled by a smooth-surfaced sheet of Illinoian (and Iowan?) ground moraine.

CHAPTER VI—POST-GLACIAL GEOLOGY

Lake Chicago[1]

ORIGIN

As soon as the Valparaiso ice-sheet had retreated from the Joliet area, post-glacial history for this region began, but a gradually retreating ice-sheet covered the area adjacent to the northeast for a long time. Even today an ice cap covers most of Greenland; the ice age for Greenland is not past.

After the formation of the Valparaiso moraine, the ice retreated a few miles, but later reached another stage of equilibrium, when the diminutive (in Illinois) Lake Border morainic system was formed (fig. 26). While the ice was making this moraine, a small crescent-shaped lake appeared between its edge and the Valparaiso moraine. After the formation of the Lake Border moraine, and while the ice was retreating, this lake continued in existence, gradually growing larger, although probably temporary advances of the ice front may have reduced its area at times. This lake has been called Lake Chicago and was the lake from which Lake Michigan developed.

When this lake first formed, its outlet was the lowest accessible gap in the Valparaiso moraine. This seems to have been where Des Plaines River now crosses the moraine, near Lemont (T. 37 N., Rs. 10 and 11 E.). As the ice retreated, the lake increased in size, and at the same time received more water from the melting ice and therefore had a greater outflow. The channel by which this outlet crossed the Valparaiso moraine was probably eroded rapidly, for the till, presumably with little or no vegetation on it, offered but slight resistance. The water formed by the melting ice, although heavily laden with glacial debris, dropped it in the still water of Lake Chicago. Thus the outlet waters were relatively clear, and with the velocity acquired by a gentle sloping outlet gradient, were able to erode effectively the unconsolidated drift. At this time, the valleys of the three sloughs of the Joliet quadrangle and Des Plaines Valley were filled more or less with glacial outwash, largely from the Valparaiso ice-sheet. It seems probable that the outlet waters from Lake Chicago were not at this time limited to Des Plaines Valley. They probably flowed out through all the sloughs also, subjecting them to erosion. Gravels that had previ-

[1] For the data on the stages of Lake Chicago presented in this chapter, the writer is indebted to Leverett and Taylor, The Pleistocene of Indiana and Michigan, U. S. Geol. Survey Mon. 53, pp. 316-469, 1915.

ously been deposited in them were partially swept out to merge with the gravels of the Plainfield gravel plain. The waters which carried these gravels out from the sloughs, as soon as they were unrestricted by the slopes bordering the sloughs, spread out and formed distributaries, dropping much of their load, and furrowing the gravel plain. Pronounced channels which originated in this way are today apparent on this plain. Lilly Cache Creek (T. 36 N., R. 9 E.) flows in one of them through parts of its course. A prominent abandoned channel of this type may be seen in central section 2, Plainfield Township (T. 36 N., R. 9 E.). The 600- and 610-foot contours just east and south of Plainfield show others. Cross-section B-B, Plate I, also brings out the uneven surface of the plain.

STAGES

Three stages of Lake Chicago, when the water level remained nearly constant over a marked interval, have commonly been recognized. These are known as: (1) the Glenwood stage, with a level of 638 feet, (2) the Calumet stage at 616 feet, and (3) the Toleston stage at 599-606 feet. The elevation of Lake Michigan is 581 feet. Evidence is presented here indicating another stage, which had a level near 600 feet. This stage followed the Glenwood and preceded the Calumet, and is called the Evanston stage in this report.

So long as the outlet was cutting through Valparaiso till, Lake Chicago could have had no constant level, but was gradually being lowered. The existence of this early Lake Chicago has not been proved by beaches, or wave-cut terraces or other shore phenomena of standing bodies of water, since the level sank too fast and too regularly for pronounced topographic features to develop. But as soon as the outlet had cut through the Valparaiso moraine, and perhaps other drift obstacles below, it encountered the Joliet outwash plain. In the outlet area, this "gravel" sheet consists in large part of coarse, cross-bedded sandstone with a noticeable amount of conglomerate firmly cemented by calcium carbonate. The maximum observed elevation of the top of this stratum is about 635 feet in this area, although locally the top is as low as 625. Its thickness is unknown, as its lower part is covered by till which has slumped down from above, but large boulders of firmly cemented sandstone and conglomerate 6 feet in diameter seen at the base of the slope prove that it is at least 6 feet thick. Most of the outcrops of Joliet sandstone and conglomerate are found on the south side of the valley, but the rock is present on the north side at the abandoned gravel pit in the southeast corner of section 23, Du Page Township (T. 37 N., R. 10 E.), where a 4-foot section of firmly cemented conglomerate is overlain by gravel and underlain by highly calcareous brown sand.

GLENWOOD STAGE

The reason why the lake level remained at about 638 feet during the Glenwood stage is not definitely known. It can best be explained by the presence of a barrier in the outlet valley near this level. Although it has not been proved that the sandstone stratum near Lemont was cemented when Lake Chicago existed, assumed cementation at this time offers a logical solution of the barrier problem. The fact that a hard sandstone stratum appears on both sides of the outlet valley near Lemont indicates that it once formed a continuous layer across the valley. It is obvious that such a barrier would act as a dam to the outlet waters, and the rate of down-cutting of the channel would be suddenly and markedly slowed down when the overlying till was cut through.

Contemporaneous with Lake Chicago, a lake formed in the Erie basin which first drained to the southwest via a course in part that of the Wabash River. As the ice-sheet retreated, a lower outlet for this lake was uncovered to the northwest across central Michigan (in part in the valley of Grand River), and the waters from this lake joined those of Lake Chicago near the present site of Grand Haven, Michigan.

The addition of this water to that flowing from Lake Chicago increased the rate of erosion of the outlet. The possible sandstone barrier near Lemont was cut through, and once more the outlet was relatively rapidly lowered since unindurated drift was the only obstacle. Soon after this, the channel through Mink Creek slough was abandoned, as is shown by the fact that its highest point is about 625 feet above sea level. It is inferred that the other channels were lower, and carried water after Mink Creek slough ceased to be an avenue of discharge. Not long after this, Lilly Cache slough was abandoned, the highest point in its bottom being approximately 615 feet above sea level. The reason for the abandonment of this channel probably lies in the fact that bed rock was encountered at about this level in the western part of the slough, and this retarded further downcutting. Bed rock is shown close to the surface in Lilly Cache slough in section 31, T. 37 N., R. 10 E. (Pl. I). The other two channels were lowered and soon carried all the outlet waters.

Downward cutting of the outlet channels must have continued relatively rapidly until the bed rock surface was reached in the channel near Lemont probably at an elevation of about 590 feet, although the exact elevation is not known. When this level was reached, erosion proceeded very slowly and downward cutting practically ceased because of the hardness of the dolomite, and because the waters flowing from the lake were relatively clear. Moreover, once the channel had been lowered to bed rock, there was little material for the water to pick up and use as tools with which to abrade the dolomite. Below Romeo the channel still contained

glacial debris which the waters continued to erode, thus acquiring tools with which to work effectively. It seems probable that Rock Run slough was abandoned about this time. As can be seen from Plate I, this slough is underlain by bed rock at a shallow depth, generally 4 to 5 feet throughout its whole length. Dolomite actually outcrops at a few places. The highest point in the bottom of this slough is about 587 feet, and by the time the channel at Lemont was cut down to 590 feet, it is probable that all the waters followed the present course of the Des Plaines, where, in the neighborhood of Joliet, no bed rock had yet been encountered. It is possible but not probable that a little later, when the volume of water coming out from Lake Chicago was greatly increased, some water for a short time once more went via Rock Run slough.

EVANSTON STAGE[2]

The barrier imposed by the dolomite in the outlet of Lake Chicago near Lemont caused a sudden cessation in the lowering of the lake level, which had been continuous from the time the lake first formed, with the exception of the Glenwood stage, believed to have been caused by the sandstone of the Joliet outwash plain. This stage of the lake, the second with a temporarily stationary level, is here called the Evanston stage from the presence of peat beds formed during its existence near Evanston.[3] Although during this stage, beaches and other shore phenomena were probably formed, these have not been differentiated from those of the later Tolesston stage. While the Evanston stage lasted, streams tributary to the outlet near Lemont, especially well seen southwest of the town, cut ravines through the till slopes of the outlet valley, bringing their bottoms below the 600-foot level.

During the time that the Evanston stage continued, important drainage changes were taking place in the Great Lakes region to the east, caused by the farther withdrawal of the ice. Eventually these changes brought this stage to an end. The lake in the Erie basin had grown, due to the retreat of the ice, until it was larger than the present Lake Erie. Another large lake which covered the area of Saginaw Bay, as well as a part of central Michigan, had also developed. Somewhat later these two lakes united, and sent their waters across Michigan to Lake Chicago. At this stage the maximum amount of water went through the Chicago outlet.

CALUMET STAGE

It is considered that at this time, when the outflow via Lemont increased to a maximum, the Evanston stage was succeeded by the Calumet stage, dur-

[2] For additional evidence favoring a pre-Calumet 600-foot level, see G. F. Wright, Explanation of the abandoned beaches about the south end of Lake Michigan: Bull. Geol. Soc. Am., Vol. 29, pp. 235-244, 1918.

[3] Alden, W. C., U. S. Geol. Survey Geol. Atlas, Chicago Folio (No. 81), p. 9, 1901.

ing which time the water stood about 616 feet above sea level. If the bottom of the channel at Lemont was at 590 feet at this time, the outlet river at this point was then some 25 feet deep and about a mile wide. It is known that the channel followed by the outlet of Lake Chicago was almost level from the lake itself nearly to Romeo. Even now the divide between Lake Michigan and the Des Plaines is only 8 feet high. The great increase of water which went via the Chicago outlet during the Calumet stage would cause the development of a higher lake level, simply because the large amount of water would tend to clog in the almost level channel above Romeo. In fact, the lake may have extended nearly to Romeo so far as the water level itself is concerned, although below Willow Springs there was probably a swift current due to the pressure of the lake water.

During this high-water stage of the outlet, it is obvious that the ravines, cut earlier by tributary streams in the till slopes of the main outlet valley near Lemont, would have been drowned where they joined the main valley. This would have resulted in the filling of the lower ends with silts, sands, and gravels brought down by the tributaries from the uplands, for the side streams would have been dammed back by the main stream. These ravines actually show this sequence of events. They were filled to a depth of some 15 feet where they join the main valley. The muds in these ravines are contorted by the weight of the overlying gravels which were deposited on them. This is well seen in the ravine in the northeast part of section 24, Du Page Township (T. 37 N., R. 10 E.).

TOLESTON STAGE

Continued retreat of the ice-sheet, by this time almost gone from the United States, uncovered an outlet for the waters of the Huron-Erie basins lower than that via Chicago. This new outlet was by way of Mohawk River, and a great part of the outflow which had passed Lemont was diverted to the east. At this stage only the waters of Lake Chicago flowed down the Des Plaines Valley. This caused the outlet level to drop again, probably to about the 600-foot level. This stage of Lake Chicago is generally known as the Toleston stage. The beaches and other shore phenomena developed by Lake Chicago during this stage are about 20 feet above the present lake, although their elevation in Illinois varies from 599 to 606 feet. These beaches are at about the same level as those of the Evanston stage, and if any of the latter remain, the two sets may not be easily distinguished.

Subsequently Lake Chicago coalesced with the predecessors of Lakes Superior and Huron. For a time, part of the drainage from this large lake went past Lemont, but soon it was all diverted to the east, because of the uncovering of a lower outlet, after further retreat of the ice. Thus, early in the history of this large lake, the Chicago outlet was abandoned never to

be used again, until in recent years man has dug a ditch in the channel of the old outlet which carries water almost negligible in amount compared with that of the tremendous river that occupied the valley at an earlier time. As the drainage was gradually diverted to the east, the level of the lake was continually lowered, and the amount of water that flowed past Lemont was ever less, until finally no water from the lake used the old channel. In times of flood Des Plaines River, the stream which inherited the tremendous valley re-excavated by the outlet of Lake Chicago, flows partly past Lemont and partly over the very low divide into Lake Michigan. Within the past century, at certain times of the year, it has been possible to paddle from Lake Michigan into the Des Plaines. But since floods on the Des Plaines have been quite destructive, a dam has been built near Riverside (the Ogden Dam) by which the flow of water is regulated.

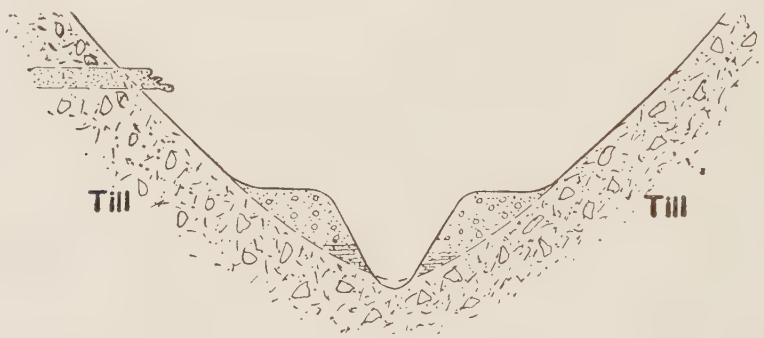


Fig. 41. Cross-section of a tributary ravine entering the south side of the DesPlaines valley about 2 miles west of Lemont. The projecting ledge is composed of sandstone. Horizontal scale: 1 inch equals 17 feet. Vertical scale: 1 inch equals 23 feet.

After the high water of the Calumet stage, with the resulting silting up of the ravines tributary to the main river near Lemont, the lowering of the water level allowed the streams in these ravines to cut through the filling, leaving its remnants as terraces. This sequence of events has been well revealed in this area by the stripping which has been done to facilitate removal of the dolomite. This stripping has exposed, in nearly vertical bluffs, cross sections of ravines as shown diagrammatically in figure 41. The original ravine, cut in till, was partially filled with silt and gravel during the Calumet stage subsequent to which the stream cut through this filling, although without removing all of it, and even into the underlying till, showing that the present ravines are cut deeper than the original pre-Calumet ravines. The tops of the terraces in these ravines are, as a rule, some 5 yards wide, rarely wider. In some places a terrace appears on only one side of a gully, any terrace remnants that may have once been present on the other side

having been completely removed. These terraces are generally composed of coarse, angular gravel, but much sand and silt, as well as some mud, especially near the base are present. The thickness of the deposit in the ravines is variable. In some sections but 4 or 5 feet of stream-laid material overlie an equal thickness of till. This type of section is common near the heads of the terraces, which shows that later erosion has brought the present valley bottom noticeably below the bottom of the pre-Calumet valley. The ravine in the SE. ¼ of section 25, Du Page Township (T. 37 N., R. 10 E.), shows a ledge of coarse, torpedo, cross-bedded sandstone jutting out at several points on its northeast side. Such a ledge is shown in figure 41. It was this sort of rock along the main valley which perhaps acted as a barrier to the cutting down of the Chicago outlet during the Glenwood stage of Lake Chicago.

Deposition and Erosion

During the time that Lake Chicago was in existence, its outlet waters, in addition to acting on the sloughs and the Plainfield gravel plain as sketched, effected certain changes in the main valley below Romeo, where it has a gradient varying from 4 to 16 feet, but averaging slightly greater than 7 feet to the mile within the quadrangle limits. This valley had been nearly filled with glacial debris when the Valparaiso moraine was formed. The outlet waters from Lake Chicago completely scoured out the old rock channel, so that now bed rock is at the surface or close to it over a belt about a mile wide extending from a point above Lemont to below Rockdale. These waters worked over the glacial debris, carrying it downstream a considerable distance. Probably the outlet waters during the early history of Lake Chicago established a channel with a bottom which, below Romeo, sloped rather uniformly to the south. When the probably cemented gravel stratum near Lemont was reached in the down-cutting process, the channel below Romeo, where there is no evidence of a cemented stratum, was lowered more rapidly than that above Romeo. In this manner, a new channel was excavated inside the old channel below Romeo, leaving remnants of the old river flat standing as terraces. On a smaller scale a similar process was repeated, so that several terraces extend from Romeo many miles downstream. The number of terraces is different at different points, but in most places three may be seen, two of gravel, the other of dolomite.

In general, the highest terrace is of gravel resting on dolomite (fig. 42, 1). This is well shown along the west slope of the valley from Romeo to Joliet, where a dolomite terrace seems to take its place, although local patches of coarse gravels, such as that near Broadway and Oneida Streets in Joliet resting on the rock, are remnants of a once more extensive sheet. Figure 43 shows a section of the gravel of this terrace, where it

rests on the flat surface of the Silurian dolomite. The elevation of the top of the terrace here is slightly above 600 feet. About 20 feet below this level, there is a dolomite terrace in the neighborhood, but it is not well-marked, and as it has a noticeably variable elevation, being higher along the west side of Joliet farther down stream, it is probable that it represents a more or less uneven rock surface which has in places been swept clear of gravels. This second terrace is not shown in figure 42, but if a part of the gravel at (2) had been removed from the dolomite surface, it would appear at this point. Below this dolomite level, at the east end of Rock Run slough, there is a terrace at about 560 feet, in which a few feet of gravel rest on dolomite (fig. 42, 3). Nearer the river there is a lower, narrow dolomite level (fig. 42, 4), and below this the alluvial plain of Des Plaines River (fig. 42, 5). Thus there are here five distinct terraces, all of which are distinguished on Plate I.

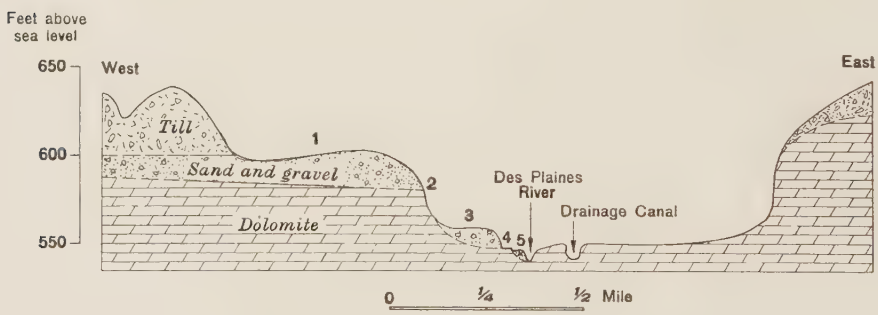


Fig. 42. East-west cross-section of Des Plaines Valley 1 mile south of Lockport.

The lower gravel terrace resting on dolomite can be seen in Joliet. It is bordered on the west by Eastern Avenue as far north as Jackson Street. The high school is on its edge, although it is not as distinct here as farther north or south, since gravels removed in the excavation for the high school annex have been dumped in the hollow at the corner of Jefferson Street and Eastern Avenue, giving a gentle westerly slope where there was a steeper one before. A section of the gravels here was well exposed by the excavations, and is shown in figure 44. The section is 14 feet deep, and solid rock was reported to be 3 feet below its base. The gravel is very coarse, 50 per cent of it being composed of stones more than 3 inches in diameter, and 10 per cent of it of boulders more than a foot in diameter. The largest boulder shown in the section here is 18 by 8 by 6 inches. The stones are only slightly rounded. They are largely slabs, which are generally horizontal in position, but locally arranged in north-dipping beds. Ninety-nine per cent of the rocks in this gravel are dolomite of local origin.

The outlet waters from Lake Chicago, besides reworking the glacial debris filling the valley, also eroded the Silurian dolomite to some extent, es-

Fig. 43. Gravel resting on Silurian (Niagaran) dolomite. Commercial Stone Company, Joliet. (NE. ¼ sec. 33, Lockport Twp., T. 36 N., R. 10 E., at the east end of Rock Run slough.)

Fig. 44. Section of the coarse gravel exposed in the excavation for the annex of the Joliet High School, Joliet.

pecially along the valley south of Romeo. Evidences of this erosion may be seen along the west bluff in the northern part of Joliet, where the photograph

in figure 45 was taken. Here the river cut into the lower part of the bluffs, leaving overhanging masses, which, however, are gradually caving down, as shown by the pile of debris at the base of the bluff, made up in considerable part of small blocks of the thin-bedded, brittle dolomite. An even better example of this undercutting may be seen near the center of section 10, Lockport Township (T. 36 N., R. 10 E.) and the adjacent area to the south.

Fig. 45. Undercutting of the dolomite at Joliet by the waters from Lake Chicago.

Other Post-Glacial Changes

Following the time when the Chicago Outlet channel was abandoned by the waters overflowing from the Lake Michigan basin, minor amounts of erosion and deposition have been effected by less-powerful agencies.

DES PLAINES RIVER

As the lake drainage gradually changed from the south to the north, due to the opening of an outlet at a lower level to the east, the upper part of Des Plaines River seems to have almost had its choice of flowing into Lake Michigan and thence to the Gulf of St. Lawrence, or down the old outlet channel to the Gulf of Mexico. The divide between these two basins, before the cutting of the Drainage Canal, was but 8 feet high, and in times of high water the Des Plaines sometimes discharged into both basins. A dam at Riverside now controls this drainage, sending most of it down the old outlet channel, now occupied by Des Plaines River. Even in flood times, when some 13,200 second-feet of water (maximum mean daily discharge) passes Joliet[4] (which includes most of the water coming down the Chicago Drainage Canal), this stream is probably not 1/10 the size of the river that once occupied this valley. Des Plaines River has had but slight effect on its big valley, largely because the old outlet river had cleaned out the valley down to bed rock, and thus any channel cut by the present stream had to be made in the solid dolomite. There are signs of slight channel cutting opposite Romeo, but elsewhere the river has accomplished little as far as can now be seen, since in its course near Lemont and at Joliet it has been confined artificially to a narrow channel.

LONG RUN

Two sets of terraces may be seen in the valley of Long Run near the place where it joins Des Plaines Valley. The higher one, some 30 feet above the creek, is probably to be correlated with the Glenwood stage of Lake Chicago. The lower terrace surface, about 12 feet above the stream, perhaps originated in Calumet times.

FRACTION RUN

As shown on Plate II, there is a rather pronounced rock hill in the SW. ¼ of section 26, Lockport Township (T. 36 N., R. 10 E.). As Chicago Outlet River swept its channels free from glacial debris, the base-level for Fraction Run was rapidly lowered. So long as Fraction Run had nothing but glacial till to cut through, its valley probably was lowered about as fast as the major stream, but when it encountered the surface of the rock hill in its bed, its rate of downward cutting was quickly lessened. The Chicago outlet, not encountering this rock hill, did not have its rate of downward cutting lessened. As a result, the major valley was lowered much faster than that of the tributary, and no doubt rapids were formed near the junction of the two. Ever since this time, rapids have been present in the lower part of Fraction Run, and the present tiny canyon is

[4] U. S. Geol. Survey Water Supply Paper 475, p. 129, 1921.

the result of the downward cutting, combined with headward advancement of the rapids. Only tiny remnants of terraces may be seen in Fraction Run.

SPRING CREEK

Spring Creek shows a single sand and gravel terrace above the present alluvial plain. The terrace, which is indicated on the map, Plate I, is due to erosion of a sand and gravel layer which is continuous on both sides of the creek under the Rockdale till. Apparently the stream cut down partly into the Joliet outwash plain, was there held up by a temporary base level, formed a wide flat, and later, by the lowering of its base level, was enabled to cut through this flat down to the present flood-plain, leaving large remnants of the old flat standing as terraces.

HICKORY CREEK

Hickory Creek, the largest tributary of the Des Plaines within the quadrangle, locally shows as many as three terraces above the present alluvial plain. These are quite irregular, however, and can be traced but short distances.

SUGAR CREEK

As in the case of Fraction Run, that part of Sugar Creek appearing on the Joliet map has cut a valley in the hard dolomite, although its canyon is much less pronounced, being less than 15 feet deep. It is an excellent place to see the jointing in the Niagaran formation, but jointing has not controlled the course of the stream, which in this section almost bisects the angle made by the two sets of joint planes.

THE RAVINE IN REED'S WOODS[5]

"One of the prettiest and most instructive examples of excavation by a tributary in the glacial drift is the ravine in Reed's woods, above Bush park in sec. 17, T. 35 N., R. 10 E. There are several features to be observed here which, taken together, cannot fail to convince one that this deep ravine and its tributaries have been carved out wholly by the activity of rain and running water.

"In the first place, the behavior of the creek and its little tributaries during wet weather is significant. The main channel at such times may be filled brim full or even to overflowing, so that the little flood-plain which forms the floor of the valley is under water. In its swollen condition the stream may be seen to carry fine sediment in suspension and to roll sand and fine gravel along the bed of the channel. Around the outside of every sharp curve—and there are many such—the stream has cut away its bank. At points where the channel swings against one side of the valley, bare slopes of glacial drift may be seen, several feet high and very steep. After a rain it is not unusual to find little pillars of clay, capped by pebbles or other protective objects, around which the rain has excavated the fine clay. Obviously, with the washing away of soil from

[5] Goldthwait, J. W., Physical features of the Des Plaines Valley: Ill. State Geol. Survey Bull. 11, pp. 60-64, 1909.

exposed side slopes and from the channel bank the ravine is changing form, be it ever so slowly.

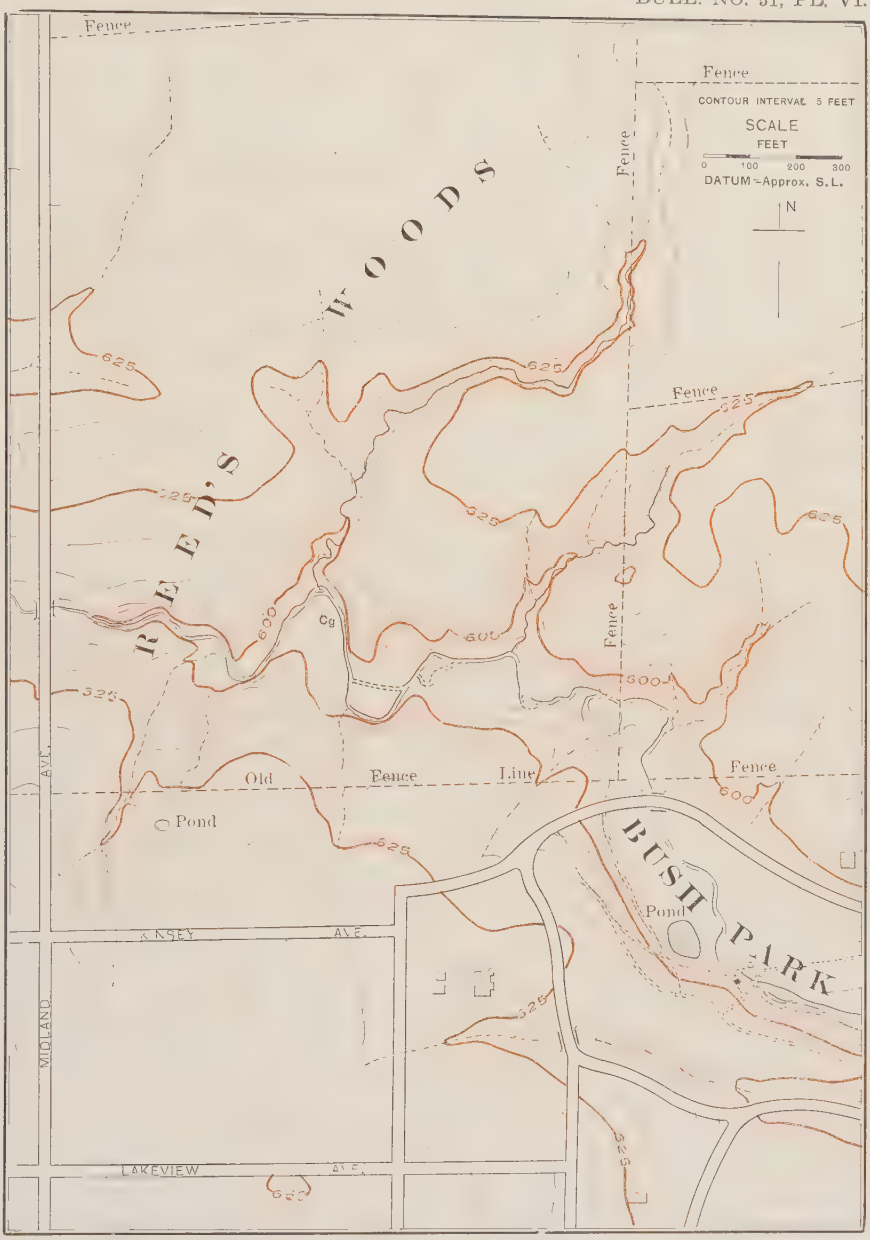
"Material thus obtained is washed into the stream and swept down-valley (except such large pebbles and bowlders as cannot be moved), to be deposited sooner or later in the channel on the inside of some curve, often directly opposite a place where cutting of the outer bank is going on. It is by this 'cut-and-fill' process that the flood-plain has been built, for even now it is being broadened by the extension of deposits on the one side and by lateral erosion on the other, at those points where the channel swings to the extreme border of the floor. In the freshly exposed channel in dry weather may be seen the stratified structure of the flood-plain, due to its having been built up under water by sediment transported by the stream. Each variation in volume of the stream means a variation in its carrying power; hence it is repeatedly depositing a layer of different texture from the preceding layers. The surface of the flood-plain is, indeed, merely a part of the waste material that is gathered up by the creek and its wet weather branches and is just now on its way down to the valley of the Des Plaines. Not only will the stream gather sediment from either side, but it will pick up material from the bed of its channel during each flood, and the channel floor will be lowered thereby. Judging from the rate at which the waste is moving down the flood-plain path—a slow rate, to be sure, operative only in wet weather, yet a perceptible one—we may believe that in the thousands or tens of thousands of years during which the drift has been exposed to running water, a ravine as large as this has been excavated. The process of transportation must needs involve excavation. The ravine, then, is constantly growing deeper as the stream cuts downward along its bed, and wider as the stream planes away the border of its flood-plain, and rain washes down the side slopes.

"In this connection it is worth while to consider the effect which excavation has at the head of a ravine. Examine, for instance, the extreme upper end of some little side ravine or gully (selecting, of course, one in which the natural conditions have not been upset by artificial drains or rubbish heaps). The one in figure 46, for instance, is a straight, steep-sided gully, usually without sod, exhibiting the sharp outlines of a recently rain-cut surface. When it rains, the water which falls in this gully and that which is shed into it cuts down its steeply inclined bed and thereby cuts back its head. The deepening and the headward growth of such a gully are inseparable. Thus, while the water is running from the head toward the mouth of a stream, the stream valley and, consequently, the stream itself, wear headward, or, as it might seem, backward. The exact direction in which the gully works back is determined partly by inequalities of surface slope, for a depression which concentrates the run-off and delivers it to the gully will cause the gully to lengthen in that direction, and partly by inequalities in structure of the ground, for if hard and soft materials lie side by side, the running water will select a path along the soft belt. Even foreign obstruction like tree roots or large bowlders serve to turn a young valley to one side, and perhaps wholly change its future course of growth. Here then, at the extreme head of a ravine, we may see the work of excavation in its infantile stages. The difference between the head-water gully and the full grown main ravine, is one not of kind, but of size. This stream has only recently worked back to the gully head, and there its volume is exceedingly small; consequently very little excavation has been accomplished. The main ravine, however, began long ago to be cut out by the growing stream, and with its growth the size and power of the stream has been increased at a more and more rapid rate.

"Another feature that demands attention is the straightness of the young gully. It is a matter of easy observation that an enlarged gully or small ravine like the one which enters Bush Creek from the north in the center of Reed's woods, follows a crooked path on its way down to the main ravine, bending back and forth between a series of projecting spurs. Where developed under favorable conditions, these bends may be exceedingly symmetrical and evenly spaced. Careful inspection and legitimate reasoning show that they represent irregularities or crooks in the incipient gully which have been enlarged and modified until they approach conventional curves as small accidental obstructions become less and less effective and the minor crooks are eliminated. While the curves which survive in this growth are slowly enlarged by outward cutting, they begin to shift distinctly down-valley. The explanation of this lies in the fact that wherever a stream winds around a spur it cuts a little more strongly against the up-

Fig. 46. Young gulley near Reed's Woods.

valley side of that spur than on the down-valley side of the spur next above. Thus, while the stream curves push their way slowly down-valley, and the spurs are slowly consumed by the trimming away of their up-valley sides, the valley itself is widened, and soon the beginnings of a flood-plain may be seen. The main ravine has passed through exactly these stages of growth. It has not only been deepened 25 feet below the upland level, but by the lateral swinging of the creek it has been widened about 150 feet. At the same time, by the down-valley shifting of its curves, the original spurs have been half trimmed away. Plate VI shows plainly the manner in which the creek is attacking the up-valley side of three half-consumed spurs in Reed's woods. Obviously this is not an accidental but a systematic relation. At these points the steep bank of the ravine is bare where the stream has recently been undermining it. Perhaps a tree



Map of the Ravine in Reed's Woods.

leaning over the creek at a precarious angle tells the same story of the continued activity. What better explanation for these phenomena than that the ravine is being and has been cut out by the creek? How else, indeed, can such a group of facts be accounted for? If there should still be doubt regarding the ability of so small a creek to excavate so large a ravine, we must consider the statement of an old-time Scotch geologist, John Playfair, who, calling attention to the manner in which side valleys of a river system join the main valley, declared, in 1802, that side valleys have 'such a nice adjustment of their declivities that none of them join the principal valley either on too high or too low a level; a circumstance which would be infinitely improbable if each of these valleys were not the work of the stream that flows in it.'[6]

"This feature, as well as the others, is illustrated in the Bush Creek ravines. They are not 'ready made' valleys fashioned for the streams; they have been slowly and laboriously cut out by the streams themselves, and testify to the changes which can be wrought out in long periods of time. This creek, it might be remarked, is probably some thousands or tens of thousands of years old."

DU PAGE RIVER

Du Page River and the tributaries which join it within the area do not occupy valleys that show signs of much erosive water action. Spring Brook occupies a valley that is several times too large for the present creek, and probably owes its origin chiefly to irregularities in deposition of the drift, although it is possible that erosive action by glacier-fed waters enlarged it. Lilly Cache Creek below Lilly Cache slough occupies a valley inherited from the time when glacial waters flowed through the slough; its valley is noticeably less well-developed above the slough.

Above the area of rock outcrops near the White School (sec. 14, Wheatland Twp. (T. 37 N., R. 9 E.), East Branch of Du Page River occupies a valley with a conspicuously broad flat bottom. As can be seen from the bed rock surface contour map, Plate II, the floor of this part of the valley is everywhere some 50 feet above the underlying bed rock surface, and the river falls about 3 feet per mile (as the crow flies), winding about in intricate fashion. In short, this area of rock near the White School has acted as a base level, to which elevation the stream in the valley above this point has attempted to bring its floor. Since its downward cutting was arrested by the hard dolomite, the river has formed meanders which stretch across the whole valley bottom, and is now working at the wall along its southeastern side, using its erosive power in widening rather than in deepening its valley. This sinuous course is a source of some trouble for farmers, and to the north of the Joliet quadrangle a dredge was at work in 1921 confining the stream to a straight artificial channel.

The West Branch of the Du Page, on the other hand, has not such a broad open valley, because all along its course it is underlain at slight depth by bed rock, which outcrops at two places. If the bed rock surface map (Pl.

[6] "Illustrations of the Huttonian theory of the earth," p. 102, 1802.

II) is correct, the valley of West Branch will be very gradually though probably very slightly shifted to the east as it degrades its valley, since the surface of the rock underlying the stream has a marked downward slope to the east. The gradient of West Branch above the White School rock area is more than twice as great as the corresponding gradient of East Branch. This is due to the fact that bed rock crops out in the valley of West Branch, which also accounts for the marked topographic difference between the two valleys.

Throughout the rest of its course, Du Page River has inherited an old channel occupied by the last glacial waters, although along the southwest side of the big bend south of Plainfield there are marked signs of erosion by the present stream, which has cut laterally into the Minooka drift sheet until it has developed a steep till slope as much as 25 feet high on its southwestern side. Along its entire course Du Page River shows only very small terrace-like flats, too small to map except locally along West Branch.

ROCK RUN

Rock Run inherited a valley, much too large for the present stream, which was formed when glacial waters from Lake Chicago flowed through Rock Run Slough. The amount of erosion accomplished by Rock Run cannot well be differentiated from the large amount done by its glacial predecessor. The interesting feature of the valley appears near the south edge of the quadrangle, where the map, Plate I, shows by the dolomite outcrops the double valley occupied by the precursor of Rock Run. The fundamental cause of the abandonment of the eastern channel cannot be confidently given, although it was presumably because the lower outlet lay to the west.

Post Glacial Fossils

Following the final retreat of the ice-sheet, various forms of life migrated into the area, some of the remains of which are now entombed in the recent deposits along the various valleys. Below is given a list of fossil mollusc shells collected from the recent deposits of the Joliet area.[7] These were identified by Mr. Frank C. Baker of the University of Illinois. Dr. V. Sterki of New Philadelphia, Ohio, identified the genera Sphaerium, Musculium, and Pisidium.

Station No. 1

Locality: East bank of Du Page River near the center of the NE. ¼ of sec. 10, Troy Township (T. 35 N., R. 9 E.).

Material: Recent alluvium, now forming the banks of the Du Page. Section consists of 4 feet of black, almost pebbleless loam covered with soil, and overlying yellowish silt. Most of the shells are from a layer about 2 feet below the sod. The shells are typical of a land fauna.

Polygyra clausa (Say) *Succinea ovalis* (Say)

[7] Baker, F. C., Pleistocene mollusca from the vicinity of Joliet, Illinois: Ill. State Acad. of Science, Vol. XV, pp. 408-420, 1922.

STATION No. 2

Locality: North bank of Du Page River in the SE. corner of the SW. ¼ of sec. 16, Troy Township (T. 35 N., R. 9 E.).

Material: Recent alluvium, now forming the banks of the Du Page; same type of material as at station No. 1. The shells constitute a river fauna, with certain land shells washed in from the bank.

Goniobasis livescens (Menke)
Planorbis trivolvis (Say)
Planorbis antrosus (Conrad)
Planorbis dilatatus buchanensis (Lea) (this is the first fossil record of this form, which is rare)
Valvata tricarinata (Say)
Sphaerium stamineum (Conrad)
Polygyra thyroides (Say) (young land shell)

STATION No. 3

Locality: West bank of Du Page River about a quarter of a mile west of station No. 1, sec. 10, Troy Township (T. 35 N., R. 9 E.).

Material: Alluvium in the banks of the Du Page. Same type of fauna as at station No. 2.

Goniobasis livescens (Menke)
Campeloma subsolidum (Anthony)
Sphaerium stamineum (Conrad)
Pyramidula solitaria (Say) (land shell)
Pyramidula alternata (Say) (land shell)
Polygyra hirsuta (Say) (land shell)

STATION No. 4

Locality: Near Rock Run in the center of sec. 11, Troy Township (T. 35 N., R. 9 E.).

Material: Shells brought up from the alluvium by some burrowing animal. Land fauna.

Planorbis campanulatus (Say)
Planorbis antrosus (Conrad)
Planorbis crista (Linn)
Planorbis altissimus (Baker)
Planorbis exacuous (Say)
Valvata tricarinata (Say)
Amnicola leightoni (Baker)
Amnicola lustrica (Say)
Amnicola walkeri (Pilsbry)
Physa warreniana (Lea)
Lymnaea elodes jolietensis (Baker)
Pisidium splendidulum (Sterki)

STATION No. 5

Locality: Bottom of Rock Run slough, 300 yards south of the center of sec. 31, Lockport Township (T. 36 N., R. 10 E.).

Material: Collected from a mud hole (alluvium). This is a fresh-water swamp fauna, different from the faunas at stations Nos. 4 and 6.

Planorbis pseudotrivolvis (Baker)
Planorbis parvus (Say)
Physa gyrina (Say)
Lymnaea elodes (Say)

STATION No. 6.

Locality: SE. ¼ sec. 15, Joliet Township (T. 35 N., R. 10 E.) above the dolomite of the abandoned dimension-stone quarry just west of Rowell Avenue and south of Linden Avenue.

Material: Gray, powdery, limonite-stained, calcareous shell marl, about 4 feet thick, containing a land and fresh water fauna, probably showing a change from fresh water to land conditions of sedimentation.

Land

Pyramidula solitaria (Say)
Polygyra thyroides (Say)
Polygyra clausa (Say)
Strobilops affinis (Pilsbry)
Zonitoides arborea (Say)
Succinea retusa (Lea)

Fresh-water

Planorbis campanulatus (Say)
Planorbis antrosus striatus (Baker)
Planorbis trivolvis (Say)
Planorbis altissimus (Baker)
Planorbis parvus urbanensis (Baker)
Planorbis deflectus (Say)
Valvata tricarinata (Say)
Valvata tricarinata perconfusa (Walker)
Amnicola leightoni (Baker)
Amnicola lustrica gelida (Baker)
Physa warreniana (Lea)
Lymnaea elodes jolietensis (Baker)
Pisidium splendidulum (Sterki)
Sphaerium rhomboideum (Say)

STATION No. 7

Locality: Joliet Fair Grounds.

Material: Marl. Collected by Mr. J. H. Ferris of the Joliet Daily News. Fresh water shells in the lower layers, land shells in the upper layers.

Land

Polygyra albolabris (Say)
Polygyra profunda (Say)
Polygyra multilineata (Say)
Polygyra multilineata algonquinensis (Nason)
Polygyra thyroides (Say)
Polygyra clausa (Say)
Polygyra pennsylvanica (Green)
Polygyra hirsuta (Say)
Circinaria concava (Say)
Zonitoides minuscula (Binney)
Gastrodonta ligera (Say)
Pyramidula alternata (Say)
Pyramidula solitaria (Say)
Helicodiscus parallelus (Say)
Succinea retusa (Lea)
Succinea avara vermeta (Say)
Strobilops labyrinthica (Say)
Pupoides marginatus (Say)
Vallonia gracilicosta (Reinhard)
Carychium exile (H. C. Lea)

Fresh-water

Sphaerium sulcatum (Lam.)
Musculium rhomboideum (Say)
Musculium secure (Prime)
Pisidium variabile (Prime)
Pisidium compressum (Sterki)
Pisidium pauperculum (Sterki)
Pisidium minusculum (Sterki)
Valvata tricarinata (Say)
Valvata tricarinata perconfusa (Walker)
Pomatiopsis lapidaria (Say)
Amnicola leightoni (Baker)
Amnicola lustrica gelida (Baker)
Lymnaea stagnalis appressa (Say)
Lymnaea haldemani (Desh.) Binney
Lymnaea caperata (Say)
Lymnaea dalli (Baker)
Lymnaea obrussa decampi (Streng)
Lymnaea elodes jolietensis (Baker)
Physa warreniana (Lea)
Physa gyrina (Say)
Planorbis campanulatus (Say)
Planorbis antrosus (Conrad)
Planorbis antrosus striatus (Baker)
Planorbis deflectus (Say)
Planorbis altissimus (Baker)
Planorbis parvus urbanensis (Baker)
Ancylus parallelus (Haldeman)

Resumé of Post-Tertiary History

Following the long interval of pre-Glacial erosion, several great ice-sheets probably advanced over the area. The deposits formed by the last (Wisconsin) ice-sheet are the only ones identified within the quadrangle. Three somewhat distinct till sheets of late Wisconsin age, the first and second of which are separated by a widespread gravel layer known as the Joliet outwash plain, cover nearly the entire surface of the area where the Silurian dolomite itself does not outcrop. Following the deposition of the latest (Valparaiso) drift sheet, as the ice front retreated into the Lake Michigan basin, the ancestor of this lake was formed. The outlet waters from it flowed through valleys crossing the Joliet quadrangle, profoundly modifying their character. Later, as the drainage of the Great Lakes gradually assumed its present form, this southern outlet was slowly abandoned, and swampy conditions obtained within the main outlet valley, now occupied by Des Plaines River, as shown by beds of calcareous marl along this valley between Lemont and Lockport and near Joliet. These marl beds contain numerous fossil shells, mainly mollusca, of recent and present forms of life. Similar fossils can also be collected from the alluvial plains of the present streams, and are especially abundant along Du Page River just above and below Grinton and along East Branch of this river.

Since the time when the drainage of the Great Lakes was diverted to the east, the streams of the district have modified their own valleys somewhat, but the topography of the area as a whole has not been greatly changed. A large part of the district probably soon became covered with grass and forest, preventing wind action from having any great modifying effects, and developing a covering of soil over a topography that had lost almost none of its essential glacial characteristics. In very recent years, however, swamps and ponds have been drained, forests cut down, and the land plowed, so that it is now more easily attacked by wind and water. Man has further shown his influence as a geologic factor by digging canals and confining streams.

CHAPTER VII—ECONOMIC GEOLOGY

General Statement

From a careful study of the origin and geologic history of the valuable mineral resources, and by the preparation of a map showing their extent and distribution, the geologist generally can estimate the amounts of workable material present, as well as the more favorable locations for future prospecting and development work in any given territory.

With the origin of the various classes of material within the limits of the Joliet quadrangle in mind, it is possible to consider intelligently those substances which are of economic value to man. Among these, dolomite, sand and gravel (including molding sand), and water resources are of major importance. Of less importance are clay, marl, peat and muck, and boulders in the drift. The possibility of finding oil in commercial quantity is also considered. Soils, although of fundamental importance to agriculture, will not be discussed in detail.

Dolomite

Outcrops of dolomite and localities where it is buried by less than 10 feet of gravel or alluvium are shown on Plate I.

Along the southern edge of the SE. ¼ of section 14, Joliet Township (T. 35 N., R. 10 E.), and in the central part of section 20, Du Page Township (T. 37 N., R. 10 E.) the dolomite is buried by less than 10 feet of till. These two areas are not mapped, however, because their boundaries were not determined accurately. Possible quarry sites are abundant along the Des Plaines Valley, but favorable locations are limited to areas near some railroad where the overburden is not too great and water will not be too abundant. In general, the higher the elevation of a quarry, the less difficulty with water will be encountered. As a rule, the upper strata of the dolomite contain chert in such large quantities that they yield a relatively poor commercial product. The locations of present as well as of abandoned quarries are indicated on Plate I.

The main uses of dolomite from this area are for road metal, concrete, flux, agricultural purposes, building stone, and sidewalks. In the past years, a good deal of the dolomite has been used as building stone and in the construction of sidewalks, but at present neither building nor flagstone is being produced within the area. The Swan-Medin Company quarry in SE. ¼ section 15, Joliet Township (T. 35 N., R. 10 E.), shows a 10-foot face of good dimension stone, but operations have been at least temporarily suspended.

With the exception of the State Penitentiary quarry near the center of section 3, T. 35 N., R. 10 E., the total output of dolomite from the Joliet area is produced by the National Stone Company in the east part of section 21, and the Markgraf Stone Company in the SW. ¼ of section 16, Joliet Township (T. 35 N., R. 10 E.). The quarry of the Gross and McCowan Lumber Company (formerly the Commercial Stone Company) in the NE. ¼ of section 33, Lockport Township (T. 36 N., R. 10 E.) has at least temporarily suspended operations. The only other quarry that recently produced much rock is that of the Western Stone Company in the north part of section 22, Joliet Township (T. 35 N., R. 10 E.), which has not been operated since 1913, but which can presumably be readily reopened in case of sufficient demand.

A description of the physical and chemical character of the dolomite is given in Chapter III. Undoubtedly the amount of good dimension stone available is limited, and with the present tendency towards the use of brick and artificial stone, it seems fairly certain that the dimension stone industry of this area is not a growing industry. On the other hand, the great abundance of dolomite suitable for road metal, concrete aggregate or for agricultural purposes, combined with its ready accessibility and the good transportation conditions, points to an increase for these purposes.

The production, in the summer of 1921, from the three operating quarries in the area averaged between 1200 and 1500 tons per day, of which the National Stone Company produced about two-thirds. The production in 1920 was at least one-fourth greater, due partly to the fact that the Commercial Stone Company was then quarrying. The very large number of abandoned quarries shown on Plate I indicates that the stone industry has played no small part in the economic history of the area.

The "spoil banks" along the Chicago Drainage Canal (fig. 47) are a potential source of dolomite and the stone from these has been used for rip-rap in Cook County. Allowing 40 per cent for voids, Mr. J. E. Lamar of the State Geological Survey[1] has estimated that there are some three and one-half million cubic yards of this material available in Will County.

Sand and Gravel

The Joliet area is particularly well supplied with sand and gravel, the product of the ice-sheet or of the water from it. Sand and gravel, together with minor amounts of sandstone and conglomerate, are designated by the same symbol on Plate I, which gives their areal distribution and the location of sand and gravel pits including those that are abandoned. Possible sand and gravel pits, however, are not limited to the areas of sand and gravel

[1] Krey, Frank, and Lamar, J. E., Limestone resources of Illinois: Ill. State Geol. Survey Bull. 46, p. 194, 1925.

shown on the map, since locally the drift contains irregular pockets of these materials. There are several pits of this type in the central and south-central parts of Du Page Township (T. 37 N., R. 10 E.). Kames and eskers are also a possible source of gravel. Moreover, the Joliet outwash plain commonly extends under the till sheets (Pl. I, sections), thus having a much greater extent than is shown on the map, and material from it can in some cases be easily obtained by a slight amount of stripping.

Most of the sand produced in the Joliet area is used for building purposes, but there is also a small output of molding sand. Few deposits are sufficiently clean so that sand may be shipped from them without screening out the pebbles and washing out the clay. In fact, the Chicago Gravel Company's plant at Plainfield, which is by far the largest single producer, obtains its sand from screening the gravel of the Plainfield gravel plain,

Fig. 47. "Spoil banks" at Romeo. The ridge here averages more than 50 feet in height and 150 feet in width at its base.

which probably averages about 40 per cent sand (particles smaller than ¼ of an inch). Lake Renwick (fig. 38) is an artificial body of water made by the excavations of the Chicago Gravel Company since 1910. This lake which is more than ½ a mile in length, has a surface elevation of 590 feet, some 15-20 feet below the level of the surrounding gravel plain. It is reported that dolomite underlies the water level 4 to 6 feet at the north end, and about 14 feet at the south end, which shows that the thickness of the gravel is quite variable. The range is between 22 and 31 feet, with an average of about 25 feet. Since the surface of the gravel sheet, although furrowed by channels, is roughly more or less a plane with a distinct slope to the south, any considerable variations in thickness probably are due to irregularities in the surface of the underlying dolomite. Two counts on

different sized pebbles in the Plainfield gravel plain gave practically the same result: 95 per cent dolomite, 3 to 4 per cent chert, and 1 to 2 per cent igneous rocks (dolerites in both cases).

There are no other large producing sand or gravel pits in the area, although the Romeo Sand and Gravel Concern, which was incorporated in 1921, is a potential producer. This property, located in the bluff at Romeo, was examined by Chicago engineers who determined by drilling that the glacial outwash (nearly all sand) extends under the Valparaiso till. The sand layer is about 30 feet thick, rests on dolomite, and has a fairly level upper surface, although the overlying till surface slopes notably upward towards the east. Figure 31 shows a view of the pit as it was in 1921, with the overlying till resting unconformably on the sand which doubtless belongs to the Joliet outwash plain. It crops out in the neighboring gulleys as would a horizontal rock stratum. The limits of the eastward extension of this sand layer are unknown, but it probably extends farther than would be profitable to strip the overlying till, which rapidly thickens to the east. The company expects to ship building sand and gravel to Chicago via the electric line, and a short spur has been built to the pit.

When there is a demand there are a few sand pits near Joliet operated on a small scale to furnish part of the local building supply. These are located in the south wall of Spring Creek in the SE. ¼ of section 2, T. 35 N., R. 10 E. Sand pits on the whole are quite rare.

The Illinois Molding Sand and Material Company, which has removed molding sand from two pits in the bluff southeast of Joliet, has recently opened a new pit in the south-central part of section 14, T. 35 N., R. 10 E. The company expects to have an output of 400 tons per day, which will be sold to the steel mills for making molds in which iron and steel may be cast.

Molding sand seems to be any material suitable for making molds. It must have a marked cohesiveness, be refractory, and should possess certain other less important physical properties, such as permeability to gases, and durability. Steel molding sands generally are composed of more than 97 per cent silica. The molding sand near Joliet is Rockdale till, rather free from stones. It is removed from the top of the bluff, the section showing about three feet of soil and non-calcareous clayey material overlying 4 feet of molding sand, which in turn overlies three feet of stony till.

In certain areas there are numerous small gravel pits, the material from which is put only to local uses, such as paving near by roads and surfacing yards. The Chicago Gravel Company produces gravel which is used in concrete work and as railroad ballast.

Water Resources[2]

The waters of the region are essential to all industry and agriculture, and are therefore of vital importance. In general, there is an abundant supply, although it is in many cases "hard."

The permanent springs observed are all small. The largest noted is four miles east of Joliet in the southwestern part of section 8, New Lenox Township (T. 35 N., R. 11 E.). It is enclosed by a small, circular brick structure and flows out of the glacial drift. Numerous small springs were seen issuing near the base of the rock walls of the Des Plaines Valley, many of which flow out along bedding planes and joints in the dolomite, and are probably permanent. The best example noted was in the west wall, just east of the New Penitentiary, but others were seen in the southeast wall southwest of Lemont, and southeast of Joliet at old quarry sites. Numerous intermittent springs flow from unconsolidated banks of which the best example is seen on the east side of Rock Run near the center of the NE. ¼ of section 14, Troy Township (T. 35 N., R. 9 E.).

Of the 340 well records obtained within the Joliet quadrangle (Tables 8 and 9), about 25 are for wells more than 200 feet in depth. Ninety of the remainder are between 100 and 200 feet in depth. From these records it therefore appears that more than ⅔ of the wells are less than 100 feet deep. Most of the farms on which much stock is kept have wells that penetrate the solid rock and with one exception, the wells penetrating solid rock furnish an abundant supply of water for agricultural purposes. The well (No. 75) on the farm of Mr. Clow near the White School in section 14, Wheatland Township (T. 37 N., R. 9 E.) was drilled to a depth of 478 feet, but failed to furnish an adequate water supply.

Most of the rock wells derive their water from the Silurian dolomite, which commonly furnishes relatively "soft" and pure water, but locally contains some hydrogen sulphide. A few wells enter the Galena-Platteville formation which furnishes water similar but generally somewhat "harder" than that in the Silurian dolomite.

Numerous wells less than 50 feet deep, too shallow to reach consolidated rock, furnish the water necessary for the farms without many cattle. Wells east of Du Page River in the drift areas which reach to the base of a gravel stratum—especially if this is the Joliet outwash plain—are very likely to give an abundant water supply. The depth necessary varies with the elevation of the drilling site; in general, the higher the site, the deeper must be the well to reach water. Variations in the thickness of the over-

[2] Anderson, C. B., The artesian waters of northeastern Illinois: Ill. State Geol. Survey Bull. 34, 1919. Bulletin 34 has been freely used in the preparation of this section, and reference should be made to it for more detailed information bearing on this subject.

lying till and of the gravel sheet also influence the depth required. Most wells located on the Plainfield gravel plain furnish sufficient water for farm use at depths of about 20 feet.

The depth necessary to drill at any point in order to reach bed rock can be obtained with approximate results from Plate II. By subtracting the elevation of the bed rock surface contour from the elevation of the well site (determined from the brown contour lines on the map) the thickness of the drift overlying the rock may be determined. Wells which derive their water supply from the solid rock are preferable, because in general the supply is more constant, and the chance of contamination less. Moreover, deep wells are likely to strike a water horizon where the pressure is rather high which tends to force the water up, and less pumping is therefore required. Deep wells of this type are now known as artesian wells, even though they do not flow.

The rock formations underlying the Joliet area yielding the most water are the St. Peter sandstone, the Prairie du Chien series, and the Croixan sandstone (popularly called "Potsdam"). The "Potsdam" is the best aquifer and is reached at depths of from 700 to 900 feet below sea-level (Pl. III), or 1200 to 1700 feet below the surface, depending upon the location within the quadrangle and the elevation of the drilling site. The present wells producing from this sandstone in this area penetrate it at depths between 1235 and 1430 feet. From a study of the deep wells plotted (Pl. III) and the contour map (Pl. II), it would not be difficult to determine within less than 100 feet the depth necessary to drill in order to penetrate the Croixan sandstone within the limits of the quadrangle. In general, the water from this sandstone, is very abundant, but highly mineralized and "hard." However, water from near the top of the formation is generally satisfactory for city use, and furnishes the supply for Joliet, Lockport, and part of that at the new penitentiary.

Rockdale and the old penitentiary get water from the St. Peter sandstone. Plainfield, Dellwood Park, the new penitentiary in part, and the E. Washington Street well in Joliet derive their water from the Prairie du Chien series (New Richmond sandstone and Oneota dolomite).

The level of the water in the various artesian wells is not constant; in general it is gradually being lowered. Farmers southeast of Joliet report that in late years the large amount of water pumped from the solid rock for use of the city has noticeably lowered the water level in their wells. Anderson[3] states that in 1899 the deep city wells at Joliet had a water level of about 575 feet (some 40 feet above the surface), whereas in 1915 this level was at about 455 feet or 85 feet below the surface, a lowering of 125 feet in 16 years.

[3] Idem, p. 215.

Recent analyses of the deep well waters of the area made by the Illinois State Water Survey are given in the following table:

TABLE 7.—*Analyses of artesian waters of the Joliet Quadrangle*

	Joliet	Lockport	Plainfield
Laboratory number	39358	30866	37339
Parts per million of—			
Potassium	16.9	21.0	5.5
Sodium	92.3	190.0	82.3
Ammonium	.7	.5	.....
Magnesium	22.7	48.4	41.3
Calcium	58.0	144.7	86.8
Iron	0.0	.1	.6 (as Fe_2O_3)
Alumina	.6 (as Al)	2.3	2.9
Nitrites	.....	.04	.....
Nitrates	.7	10.6	44.2
Chloride	43	410	44
Sulphate	109.0	188.4	127.2
Residue	515	.....	.....
Silica	13.9	14.0	8.9
Manganese	0.0	.....	.....
Alkalies	264	.....	.....

Hypothetical combinations

	Parts per million	Grains per gallon	Parts per million	Grains per gallon	Parts per million	Grains per gallon
Potassium Nitrite	.....	.....	.1	.01	.....	.....
Potassium Nitrate	1.1	.06	17.3	1.01	14.2	.83
Potassium Chloride	31.9	1.86	27.2	1.59	.....	.....
Sodium Nitrate	.....	.....	.....	.....	48.7	2.84
Sodium Chloride	46.2	2.69	482.2	28.13	72.6	4.23
Sodium Sulphate	161.1	9.40	.....	.....	124.9	7.28
Sodium Carbonate	54.7	3.19	.....	.....	.....	.....
Ammonium Chloride	.....	.....	1.5	.09	.....	.....
Ammonium Carbonate	1.9	.11	.....	.....	.....	.....
Magnesium Chloride	.....	.....	139.6	8.14	.....	.....
Magnesium Sulphate	.....	.....	62.8	3.66	53.6	3.12
Magnesium Carbonate	78.7	4.59	.....	.....	105.6	6.15
Calcium Sulphate	.....	.....	196.0	11.43	.....	.....
Calcium Carbonate	144.7	8.44	217.2	12.67	216.7	12.64
Iron Carbonate	.....	.....	.2	.01	.....	.....
Iron Oxide	.....	.....	.....	.....	.6	.03
Alumina	1.2	.07	2.3	.13	2.9	.17
Silica	13.9	.81	14.0	.82	8.9	.52
Bases	.....	.....	2.0	.12	1.0	.06
Non-volatile	2.5	.15	.....	....	.....	.....
Total	537.9	31.37	1162.4	67.81	649.7	37.87
% Error	+2.6	.....	4.9	.....	.49	.....

Clay

There is no commercial utilization of the clay in the Joliet area at the present time. Formerly the company which exploited Joliet Mound manufactured drain tile from the lacustrine clays lying under the gravels, mixing the blue lake clays with some of the stoneless till that outcrops in the bluff near this point.

In 1883 a tile factory was built and a clay pit operated southwest of Plainfield in the southeastern part of section 17, T. 36 N., R. 9 E. About 1906 a new pit was opened near the center of section 20 of the same township and jugs were manufactured. The material used was Minooka till, which was remarkably free from stones. The upper yellow oxidized till was stripped off, and fresh blue till was used in the factory. About 1916 the plant was closed because of competition with new companies to the south.

Although there are small amounts of lacustrine clays in the Joliet area, they are probably too limited in extent to be of very great commercial importance. There is an abundance of till or glacial clay, a large part of which is remarkably free from stones, but in the near future it seems very doubtful if this class of material will be exploited on any large scale.

Marl

Marl is an impure calcareous clayey material which is not uncommon in the valley of the Des Plaines, but is limited in extent. It would be valuable as a fertilizer or in the cement industry if present in deposits sufficiently large to be worthy of exploitation. It commonly contains numerous fresh-water mollusc shells and was deposited under swampy conditions. Its presence in the Chicago Outlet Valley is the result of the swampy conditions which obtained on the valley floor immediately after the lake waters were diverted. Small deposits were noted above the quarry of the Swan-Medin Company ½ mile southeast of Joliet near the corner of Rowell and Linden Avenues, along the north side of the Des Plaines Valley in the NW. ¼ of section 26, and in the SW. ¼ sec. 24, Du Page Township (T. 37 N., R. 10 E.) and below Romeo along the east wall of the valley.

Peat and Muck

Peat was noted at one locality only—in the SW. ¼ of section 24, Du Page Township (T. 37 N., R. 10 E.). The deposit here is associated with marl and is very limited, as it is exposed only in the walls of a small gully which cuts through a narrow terrace. Muck, a black swampy soil formed by the decay of vegetation, is quite common in the Joilet area, and locally finds a minor use as a lawn and field dressing. Nearly all the

marshy areas indicated on Plate II contain more or less muck. The larger deposits of muck are indicated on Plate I along with alluvium, both being shown by the same symbol. In general, the alluvium is found along the present stream courses, and most of the muck occurs in the swamps in the northeastern part of the quadrangle, and in section 25, Plainfield Township (T. 36 N., R. 9 E.), and section 7, New Lenox Township (T. 35 N., R. 11 E.).

Boulders

Many of the houses in Joliet and elsewhere within the quadrangle have foundations composed of boulders of igneous rock obtained from the drift. Rarely, whole houses are made of them, and such houses form a pleasing contrast to those made of the more common types of building material.

Oil Possibilities

In considering the possibility of oil in commercial quantity in the Joliet quadrangle, the geologist takes into account four factors: (1) oil seeps; (2) structures favorable for the accumulation of oil; (3) the presence of a formation which is capped by an impervious layer such as shale and which is known to contain oil in neighboring areas; and (4) the records of the deep wells already drilled.

No oil seeps are known within the area. The presence of an oil-like film on the surface of standing water is often due to ferric hydroxide, and such films should be carefully investigated before hope of oil development is built on them.

Structures favorable for the accumulation of oil are of many kinds. Two common types are anticlines (up folds) and domes of bedded rock. The dip and strike of the dolomite were observed at many localities, and some of these are plotted on Plate I. In general it can be seen that no steep dips were observed, although at three points dips of more than 10° were read. In most cases the dip was not continuous for any considerable distance, but an opposite dip of like degree was soon met. Because of the brittle nature of the dolomite, it is considered that such folds as were observed probably are shallow, and tell little of the true underlying structure. The most favorable area for the possible accumulation of oil, based purely on consideration of these surface structures is in the central part of section 16, Troy Township (T. 35 N., R. 9 E.). Here the beds dip in such a manner as to indicate a gentle anticline with east-west strike.

In northwestern Indiana in Lake, Porter, and Jasper counties, some 50 to 60 miles east of Joliet, there are several small oil pools. The Jasper County pool, now largely abandoned, is in Devonian strata. The pools in the other counties, neither of which was of much commercial importance,

have wells which made a "good showing of oil" in the Trenton limestone[4] of Ordovician age.

The Galena dolomite which presumably underlies the entire Joliet quadrangle beneath the Richmond shale, is probably to be correlated with the Trenton of Indiana.

Wells drilled at Joliet, Lockport, Lemont, and Plainfield penetrated Galena dolomite, but encountered no oil in noticeable amounts. This formation at Lockport and Joliet, and in between these two cities, has been penetrated by so many wells that there seems to be no possibility of obtaining oil from it in this part of the area. Elsewhere within the quadrangle the absence of oil has not been proved, except at Lemont and Plainfield. However, all available evidence points to the conclusion that oil will not be found in commercial amounts in the area, and any drilling for oil would be of the "wild-cat" type with slight chance of success.

In the summer of 1921, an individual with a "divining rod" told several farmers in Wheatland Township that their farms were underlain by oil. The "divining rod" is based on no scientific principle, and anyone who invests in an oil-development project based on "divining rod" methods, is almost sure to lose.

Soils

The Illinois Agricultural Experiment Station has not yet published a soil report of Will County. The soil survey of Du Page County,[5] which includes the northern and northeastern part of the Joliet quadrangle, shows that most of the soil lying above the glacial till consists of a brown or yellow-gray silt loam. Most of the soil above the areas of alluvium and bed rock shown on Plate I is a mixed loam, largely black in color. The soil above the sand and gravel areas shown on this map is mainly classified as a brown silt loam. More detailed information can be secured from the Joliet experiment field of 32 acres located about three miles northwest of Joliet on the electric line. In general, two tons of finely ground dolomite per acre applied every five years, is needed for acid soils, and one ton of finely ground natural rock phosphate per acre every five years, is needed for soils deficient in phosphorus. In connection with proper crop rotation and the spreading of manure, this will give the best results leading to permanent improvement of the soil.

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[4] Logan, W. N., Petroleum and natural gas in Indiana: Pub. No. 8 of the Dept. of Conservation, State of Indiana, 1920.

[5] Hopkins, Mosier, Van Alstine, and Garrett, Soil Report No. 16; Agricultural Experiment Station, University of Ill., Urbana, 1917.

WELL LOGS OF THE JOLIET QUADRANGLE[1]

Explanation of Tables 8 and 9

The wells are numbered consecutively beginning with No. 1 in the section at the northeast corner of the map and proceeding back (west) and forth (east) by sections across the map just as sections are numbered in a township. The method of locating the wells is as follows: In the column under *Township* is given an abbreviation corresponding to the township name, thus:

Twp. Name	Abbreviation	Twp. Name	Abbreviation
Downer's Grove	DG	Lockport	Lo
Du Page	DP	Naperville	N
Homer	H	New Lenox	NL
Joliet	J	Plainfield	P
Lemont	Le	Troy	T
Lisle	Li	Wheatland	W

In the column under *Section* appears the section number, which is also on the map (Plate II), from which the exact location of the wells within the sections can be obtained. The elevations of the wells are given to the nearest foot, but as they were obtained from a study of the topographic map in the field, they are subject to an error of about 5 feet.

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[1] The logs of well Nos. 15, 17, 75, 76, 87, 133, 168, 178, 181, 183, 186, 187, 219, 243, and 256 were obtained from Mr. Hartong of Plainfield; well Nos. 112, 113, 228, 262, 279, 298, 299, 304, 307, and 308 from Mr. Mathews of Joliet; well No. 230 from Mr. Norton of Lockport; well Nos. 52, 60, 268, 311, and 330 were copied from Leverett, Frank, The Illinois glacial lobe: U. S. Geol. Survey Mon. 38, pp. 651-652, 1899; and well No. 1 from Trowbridge, A. C., Geology and geography of the Wheaton quadrangle: Ill. State Geol. Survey Bull. 19, p. 73, 1912. All other shallow well logs were obtained from the owners or lessees of property upon which wells are located.

TABLE 8.—*Summarized logs of shallow wells in the Joliet quadrangle*

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
1	DG	30	771	Clay with streaks of gravel	116	
				Limestone	80	196
2	Li	26	680	Dug well. 40 feet of gravel	.....	40
3	Li	28	745	108± feet to rock	.....	138
4	Li	28	735	120± feet to rock	.....	160
5	Li	29	660	Dug well. Gravel at top	.....	30
6	Li	29	660	Dug well. No log	.....	30
7	N	25	690	Dug well. No log	.....	20?
8	N	26	700	Dug well	.....	25
9	N	28	710	75 feet to rock	.....	100
10	N	29	710	58 feet to rock. Sand near surface	.....	93
11	N	29	709	60 feet to rock	.....	110
12	N	31	700	Clay	30	
				Conglomerate	2	
				Clay	30	
				Limestone	88	150
13	N	32	705	Gravel in part. No rock	.....	45
14	N	32	712	70 feet to rock	.....	90
15	N	33	705	60 feet to rock	.....	110
16	N	35	680	Dug well. No log	.....	40
17	N	35	685	37 feet to rock	.....	108
18	N	36	674	Dug well. No log	.....	40
19	Li	31	660	Gravel	.....	18
20	Li	32	654	Gravel. Just reaches rock?	.....	40?
21	Li	33	730	110 feet to rock.	.....	130
22	Li	33	752	100± feet to rock	.....	125
23	Li	34	720	100± feet to rock	.....	128
24	Li	34	740	Till	60	
				Gravel	15	
				Till	45	
				Rock	23	143
25	Li	35	682	90± feet to rock	.....	100±
26	Li	35	675	60 feet gravel	.....	60
27	Li	36	752	Some gravel at about 50 feet (?)		
				100 feet to rock	.....	299
28	Li	36	770	Clay	25	
				Sand	10	35
29	DG	32	778	125 feet to rock	.....	150
30	DP	1	740	141 feet to rock	.....	?
31	DP	1	732	123 feet to rock	.....	?
32	DP	1	752	143 feet to rock	.....	177
33	DP	1	745	124 feet to rock	.....	?
34	DP	2	665	Gravel	30	
				Sand	20	50

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
35	DP	3	690	Gets into rock	.....	90±
36	DP	4	665	20 feet gravel	.....	20
37	DP	4	685	60 feet to rock	.....	107
38	DP	5	680	Clay above gravel	.....	42
39	DP	6	648	16 feet to rock	.....	66
40	W	2	667	32 feet to rock (some gravel)	.....	82
41	W	3	690	Enters rock	.....	100±?
42	W	4	704	68± feet to rock	.....	100
43	W	4	698	87 (or 77?) feet to rock	.....	97
44	W	4	701	80± feet to rock	.....	136
45	W	5	700	71 feet to rock	.....	87
46	W	8	700	40 feet clay	.....	40
47	W	11	670	Dug well. No log	.....	28
48	W	11	648	Clay	9	
				Rock	91±	100±
49	DP	7	652	Dug well. Gravel in bottom (?)	.....	30
50	DP	7	672	Sand in bottom (?)	.....	42?
51	DP	8	675	Clay	70	
				Rock	55	125
52	DP	9-10 11-12	725	In cemented gravel below till	.....	60
53	DP	10	728	80 feet to rock	.....	114
54	DP	10	730	80 feet to rock	.....	124
55	DP	12	765	150 feet to rock	.....	170
56	DG	7	730	70 feet to rock. Some gravel at 10± feet	.....	146
57	DG	7	730	Clay	7	
				Gravel	10	
				Blue clay	53	
				Rock	35	105
58	DG	8	755	125 feet to rock	.....	175
59	DG	17	720	96 feet to rock	.....	?
60	DP	13	760	Till	100	
				Gravel	10	
				Sand	40	
				Limestone	10	160
61	DP	13	718	80 feet clay above rock	.....	?
62	DP	13	740	96 feet to rock	.....	212
63	DP	14	721	80± feet to rock	.....	200
64	DP	14	730	60± feet to rock	.....	160
65	DP	15	702	80± feet to rock	.....	160
66	DP	15	680	Clay	40	
				Rock	100	140

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
67	DP	15	700	80± feet mostly clay above rock...	.....	104
68	DP	16	680	Clay, with coarse sand at bottom..	.....	43
69	DP	17	673	Clay	60	
				Rock	33	93
70	DP	17	653	50 feet clay above rock.....	.....	?
71	DP	18	651	45± feet clay above rock.....	.....	?
72	W	13	645	Soil	4	
				Gravel	14	
				To rock.....	40	58
73	W	13	652	Soil	3	
				Gravel	37	
				Rock	36	76
74	W	13	641	Gravel	27	
				Rock	73	100
75	W	14	635	Gravel	8	
				Limestone (thin-bedded at top)....	100	
				Shale	351	
				Limestone	1	
				Shale	15	
				Limestone	1½	
				Shale	1½	478
76	W	14	637	17 feet to rock.....		203
77	W	14	642	Gravel and blue till.....	20	
				Rock	160	180
78	W	15	643	24 feet to rock (some gravel above rock)	.....	?
79	W	15	662	34 feet to rock (some gravel above rock)	.....	?
80	W	15	650	46 feet till above rock.....	.....	?
81	W	16	668	Dug well. No log.....	.....	42
82	W	16	670	Clay and gravel.....	11	
				Hardpan	1	
				Clay and gravel.....	18	
				Rock	136	166
83	W	17	681	60 feet to rock.....	.....	110
84	W	17	681	60 feet to rock.....	.....	97
85	W	17	690	Clay	50	
				Some quicksand		
				To rock	70	110
86	W	21	670	50± feet to rock.....	.....	90
87	W	21	660	35 feet to rock.....	.....	96
88	W	21	653	30± feet to rock.....	.....	?
89	W	22	657	Till	20	
				Rock	90	110

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
90	W	22	630	23 feet yellow and blue till above rock	.....	?
91	W	24	648	42 feet clay above rock	.....	?
92	W	24	652	42 feet clay (with a little sand at the surface) above rock	.....	?
93	DP	19	637	12 feet clay above rock	.....	?
94	DP	19	648	40± feet clay above rock		?
95	DP	19	644	Gravel	25	
				Rock	75	100
96	DP	19	660	Clay	25	
				Rock	175	200
97	DP	20	652	20 feet clay above rock	.....	?
98	DP	20	660	6 feet clay above rock	.....	?
99	DP	20	659	14 feet to rock. Some gravel above rock	.....	14
100	DP	21	670	Clay	54	
				Rock	36	90
101	DP	21	665	50 feet clay above rock	.....	?
102	DP	21	680	Yellow and blue till	60	
				Rock	50	110
103	DP	22	710	45± feet clay above rock	.....	100
104	DP	22	710	55 feet to rock (with a little gravel near the surface of the ground)	.....	?
105	DP	22	720	100 feet clay above rock	.....	?
106	DP	23	695	Gravelly material	100	
				Rock	4	104
107	DP	23	725	150 (or 125?) feet to rock	.....	156
108	DP	23	720	Gravel and conglomerate	101	
				Rock	25	126
109	Le	30	760	40 feet clay	.....	40
110	Le	30	715	24 feet yellow and blue clay	.....	24
111	DP	27	711	100± feet to rock	.....	189±
112	DP	28	682	Gravel	13	
				Clay	55	
				Rock	72	140
113	DP	28	650	Soil	3	
				Gravel	.....	
				To rock	47	?
114	DP	28	664	Clay	48	
				Rock	37	85
115	DP	29	670	Gravel	52	
				Rock	38	90
116	DP	29	670	50± feet gravel above rock	.....	?
117	DP	29	657	50 feet clay above rock	.....	?

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
118	DP	29	651	Clay	45	
				Rock	56	101
119	DP	30	649	40 feet clay above rock		?
120	DP	30	652	Soil	4	
				Gravel	3	
				Clay	35	
				Rock	54	96
121	DP	30	638	20 feet clay (with a little gravel at bottom)		20
122	DP	30	640	30 feet clay above rock		?
123	W	25	639	Clay	11	
				Rock	55	66
124	W	25	630	20 feet gravel		20
125	W	25	640	Gravel	20	
				Rock	86	106
126	W	26	640	To rock	32+	
				In rock	82	114+
127	W	27	631	Till	12	
				Rock	58	70
128	W	27	642	16 feet clay (with a little quicksand at base) above rock		?
129	W	28	642	Soil	3	
				Gravel	17	20
130	W	28	642	Till	20	
				Rock	80	100
131	W	29	663	40± feet blue clay with some sand above rock		80
132	W	29	661	40± feet to rock		90
133	W	31	680	63 feet to limestone		87
134	W	31	660	67 feet to rock		88
135	W	33	638	19 feet yellow and blue clay		19
136	W	33	641	25 feet to rock		48
137	W	33	636	Clay	22	
				Fine black gravel rock	3	?
138	W	34	630	Till	20	
				Rock	60	80
139	W	34	633	Gravel		15
140	W	34	620	30 feet gravel; barely reaches rock		30
141	W	35	620	15 feet gravel		15
142	W	35	639	Gravel	23	
				Rock	47	70
143	W	36	625	20 feet gravel. 23 feet to rock		20
144	W	36	625	23 feet gravel above rock		?
145	W	36	623	22 feet gravel above rock		?

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
146	DP	32	681	81 feet hard clay (with a little gravel at base) above rock	.....	120
147	DP	34	621	20 feet gravel above rock	.....	?
148	DP	35	648	48? feet to rock	.....	86
149	DP	36	670	80 (or 70?) feet to rock	.....	114
150	Le	31	670	62 feet to rock	.....	96
151	Le	32	750	110 feet to rock	.....	174
152	Le	32	650	25 feet sand and gravel	.....	25
153	Le	32	750	90 feet to rock	.....	158
154	H	6	700	100 feet to rock	.....	110
155	Lo	1	660	70± (or 60?) feet to rock	.....	100
156	Lo	2	660	60 feet to rock	.....	178
157	Lo	3	610	10± feet to rock	.....	28
158	Lo	3	614	15 feet to limestone	.....	?
159	Lo	3	610	5 feet to rock	.....	60
160	Lo	4	652	40 feet dug. No log	.....	72
161	Lo	5	663	50 feet dug. No log	.....	150
162	Lo	5	662	62 feet to rock	.....	93
163	Lo	6	640	50± feet clay above rock	.....	104
164	P	1	634	3 feet to gravel	.....	30
165	P	1	622	Soil	3	
				Gravel	15	
				To rock	18?	18?
166	P	2	620	Gravel and yellow clay	20	
				Rock	25	45
167	P	2	620	Sand and gravel	25	
				Rock	47	72
168	P	2	600	12 feet to limestone	.....	?
169	P	4	621	Dug well. No log	.....	30±
170	P	5	648	65 feet to rock	.....	85
171	P	5	640	Sand and gravel	20	40
				Clay	20	
172	P	6	660	60± feet to rock	.....	101
173	P	6	642	45 feet to rock	.....	95
174	P	7	643	50 feet to rock	.....	101
175	P	7	640	Clay and hardpan	50	
				Limestone	25	
				Sticky slate with a few chunks of coal	15	90
176	P	7	640	Clay and hardpan	50	90
				Rock	40	
177	P	8	624	Clay, then some sand and gravel, then rock	.....	100±

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
178	P	9	612	Clay	16	
				Gravel	10	
				Limestone	31	
				Shale	64	171
179	P	9	600	Clay, with gravel (?) at bottom	.....	11
180	P	9	604	See Table 9	.....	1302
181	P	9	608	18 feet to rock	.....	?
182	P	9	610	Gravel	20	
				Rock (conglomerate?)	.....	
				Then clay	.....	?
183	P	10	609	29 feet to rock	.....	156
184	P	10	612	Gravel (?)	.....	30±
185	P	11	621	6 feet to rock	.....	75
186	P	11	620	10 feet to limestone	.....	?
187	Lo	7	622	To rock	48	
				Limestone	20	
				Shale	36	104
188	Lo	7	630	27 feet gravel	.....	27
189	Lo	7	630	Gravel at bottom	.....	20
190	Lo	8	616	Clay	20	
				Limestone	50	
				Blue soapstone (shale?) for some thickness, then limestone	.....	70+
191	Lo	9	623	17± feet to rock	.....	?
192	Lo	9	670	50 feet clay above rock	.....	93
193	Lo	9	641	30± feet clay above rock	.....	100
194	Lo	10	603	9 feet mixed gravel and clay above rock	.....	29
195	Lo	10	605	½ foot to limestone	.....	?
196	Lo	12	660	Gravel, with blue clay at base	.....	25
197	Lo	12	678	78 ? feet to rock	.....	96
198	H	8	750	130± (120?) feet to rock	.....	180
199	H	18	701	55± feet to rock	.....	105
200	Lo	13	650	10 feet to rock	.....	60
201	Lo	15	612	14 feet gravel above rock	.....	?
202	Lo	16	670	40 feet to rock	.....	130
203	Lo	17	649	Clay, with quicksand at base	.....	50
204	Lo	18	620	Gravel at 20 feet	.....	30
205	Lo	18	621	Dug well. No log	.....	30?
206	P	13	629	27 feet (some gravel) to rock	.....	72
207	P	14	601	Gravel	.....	14
208	P	15	607	30± feet to rock	.....	180
209	P	16	602	Gravel	.....	18
210	P	16	610	Blue clay	.....	20

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
211	P	16	602	Gravel with rock at base	.....	22
212	P	17	621	Clay	40	
				Rock	70	110
213	P	17	614	Clay	30	
				Rock	50	80
214	P	18	632	45 feet to rock	.....	115
215	P	19	622	45± feet to rock	.....	54
216	P	20	624	Clay	40	
				Rock	46	86
217	P	20	613	40 feet to rock	.....	?
218	P	21	601	27 feet gravel above rock	.....	?
219	P	21	603	28 feet to limestone	.....	66
220	P	22	606	20 feet gravel	.....	20
221	P	23	601	20 feet dug. No log	.....	20+
222	P	24	610	Dug well. No log	.....	32
223	P	24	615	Mostly clay; some quicksand	.....	22
224	P	24	620	Gravel, 12-14 feet		
				30 feet to rock	.....	58
225	Lo	19	640	No rock	.....	30
226	Lo	19	620	Clay	16	
				Gravel	2	18
227	Lo	20	645	30 feet to rock	.....	80
228	Lo	22	612	32 feet to rock	.....	?
229	Lo	23	568	See Table 9	.....	1922
230	Lo	23	568	Limestone	80	
				Then soapstone until sand rock (?) was struck at depth of 480± feet	.....	500
231	Lo	24	660	Dug well. No log	.....	37
232	H	19	734	80± feet to rock	.....	134
233	H	19	747	80 feet to rock	.....	120
234	Lo	26	640	Gravel	.....	15
235	Lo	26	650	Bottom in white sand	.....	28
236	Lo	26	650	Gets into rock. No log	.....	65
237	Lo	26	645	See Table 9	.....	1365
238	Lo	26	570	2 feet to rock	.....	109
239	Lo	28	648	See Table 9	.....	1095
240	Lo	28	642	See Table 9	.....	1577
241	Lo	29	640	Blue clay with streaks of gravel and quicksand	51	
				Rock	21	72
242	Lo	30	642	Soil and yellow clay	10	
				Blue clay	30	
				Limestone	50	90

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
243	Lo	30	630	42 feet to limestone (thick-bedded)	.....	150
244	P	26	601	16 feet to rock	.....	70
245	P	26	620	40 feet dug well. No log	.....	40+
246	P	26	610	Clay and hardpan (gravel) and quicksand	48	
				Rock	48	96
247	P	27	593	4 feet to gravel. No rock	.....	16
248	P	27	598	20 feet to rock	.....	67
249	P	29	614	35 feet dug well. No log	.....	35+
250	P	30	622	45± feet to rock	.....	75
251	P	30	624	Clay	45	
				Rock	83	128
252	P	34	598	Soil	3	
				Gravel	16	
				Blue clay	1	20
253	P	34	594	Gravel	.....	18
254	P	35	601	Gravel	35	
				Rock	40	75
255	P	35	596	Gravel	18	
				Limestone and soapstone	17	35
256	P	36	631	42 feet to limestone (thin-bedded)	.....	107
257	P	36	610	Gravel, perhaps	16	
				Rock	48	64
258	Lo	31	630	Reported no rock. Last 15 feet in gravel. Probably gets into rock.	.....	50
259	Lo	31	630	32 feet to rock	.....	87
260	Lo	32	630	50 feet to rock	.....	?
261	Lo	34	552	See Table 9	.....	2069
262	Lo	35	638	30 feet to rock	.....	?
263	Lo	35	640	Sand, gravel, and clay	50	
				Rock	23	73
264	Lo	35	638	Hardpan, etc.	40	
				Rock	55	95
265	Lo	36	677	Clay, gravel, and quicksand	40	
				Limestone (flinty layers in limestone 35 feet below top)	150	190
266	Lo	36	690	Clay	40	
				Limestone	30	70
267	H	31	670	40 feet to rock	.....	?
268	H	32	675	Till	68	
				Gravel	12	80
269	NL	5	680	Clay-sand	?	
				Hardpan	20±	

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
				Sand	?	
				Rock	74	220
270	NL	5	665	Water from gravel. No rock		96
271	NL	6	690	160 feet to rock		183
272	NL	6	640	No rock		25
273	J	1	651	Clay	30	
				Sand	20	
				Rock	50	100
274	J	1	610	No rock		16
275	J	2	612	Gravel	20	
				Rock	60	80
276	J	2	630	80 (or 60?) feet to rock		114
277	J	2	550	See Table 9		527
278	J	4	590	1 foot to limestone		150
279	J	5	650	53 feet to rock		?
280	T	1	614	No rock		40±
281	T	1	603	Dug well. No log		17
282	T	6	628	50± feet to rock		100
283	T	7	649	68 feet to rock		162
284	T	7	631	60 ? feet to rock		125
285	T	8	631	Clay	45	
				Rock	50	95
286	T	9	620	40 ? feet dug well. No log		40+
287	T	9	610	35 feet dug well. No log		85
288	T	10	583	5 feet to limestone		?
289	T	10	602	Gravel	24	
				Rock	41	65
290	T	10	580	Gravel	18	
				Limestone	107	125
291	T	10	578	Sand and gravel		17
292	T	11	580	Soil	2	
				Gravel	18	20
293	T	11	580	Gravel	13	
				Limestone	97	110
294	T	12	624	Dug well. No log		32
295	T	12	640	50 feet to rock		
				6 feet coal seam at 92 feet		198
296	J	7	640	Dug well. No log		40
297	J	7	660	47 feet to rock		110
298	J	8	650	37 feet to rock		?
299	J	8	670	52 feet to rock		?
300	J	9	532	See Table 9		1570
301	J	9	535	See Table 9		1560
302	J	9	533	See Table 9		1621

[a] See Plate II for location of wells.

TABLE 8—Continued

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
303	J	10	538	See Table 9	.....	1575
304	J	10	538	See Table 9	.....	1550
305	J	10	550	23 feet coarse gravel above rock	.....	23
306	J	10	550	Soil	4	
				Sand	4	
				Calcareous shell marl	3	
				Gravel	1	12
307	J	11	551	Soil	3	
				Blue clay (marl?)	7	
				Gravel	5	
				Limestone	95	
				Sandy limestone	30	140
308	J	11	585	15 feet to rock	.....	?
309	J	12	620	44 feet to rock	.....	?
310	J	12	640	50 feet to rock	.....	106
311	NL	8	650	75 feet to rock	.....	87
312	NL	8	630	Yellow till	15	
				Sand	15	
				Yellow till	18	48
313	NL	18	652	31 feet to limestone	.....	90
314	J	13	640	Clay	25	
				Sandy shell rock	1	
				Sand	6	
				Limestone	24	56
315	J	13	638	11 feet to rock	.....	69
316	J	14	610	45± feet to rock	.....	160
317	J	14	603	35 feet to rock	.....	114
318	J	14	565	See Table 9	.....	1303
319	J	15	530	See Table 9	.....	1530
320	J	16	540	See Table 9	.....	1560
321	J	16	540	See Table 9	.....	1565
322	J	18	640	50 feet to rock	.....	
				Some sand just above the rock	.....	218
323	J	18	640	40± feet to rock		?
324	T	13	615	Soil	3	
				Clay	21	
				Sand over blue clay	16	
				Rock	125	165
325	T	14	571	16± feet to rock	.....	52
326	T	15	565	5 feet gravel over limestone	.....	?
327	T	15	582	4 feet clay over limestone	.....	?
328	T	15	580	Gravel	7	
				Rock	78	85
329	T	15	586	20± feet to rock	.....	72

[a] See Plate II for location of wells.

TABLE 8—Concluded

No.[a]	Location		Elevation	Log	Thickness	Total Depth
	Twp.	Sec.				
			Feet		*Feet*	*Feet*
330	T	17	622	50 feet to rock	.....	70
331	T	21	592	Dug well. No log	.....	26
332	T	22	602	30 feet to rock	.....	130
333	T	24	596	Gravel	52	
				Rock	49	101
334	J	19	560	Gravel	45	
				Clay	15	
				Limestone at bottom	.....	60
335	J	20	548	See Table 9	.....	660
336	J	21	572	See Table 9	.....	1604
337	J	22	603	20 feet to rock	.....	80
338	J	22	615	30 ? feet to rock	.....	?
339	J	23	630	50 feet to rock	.....	126
340	J	23	638	13 feet to rock	.....	60
341	J	23	640	30 feet to rock	.....	90
342	J	23	648	40 feet to rock	.....	100
343	J	24	662	Dug well. No limestone; some conglomerate	.....	30±
344	NL	20	656	Bottom in blue clay	.....	28
345	T	26	596	Clay	18	
				Gravel	18	
				Rock		36

[a] See Plate II for location of wells.

TABLE 9.—*Correlated summarized logs of deep wells in the Joliet quadrangle*[a]

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
Plainfield city well	180[b]	P	9	604	Pleistocene system		
					Surface (sand and gravel)	25½	25½
					Silurian system		
					Niagaran and Alexandrian series		
					Limestone	164½	190
					Ordovician system		
					Richmond shale		
					Shale	85	275
					Galena-Platteville limestone		
					Limestone	340	615
					St. Peter sandstone		
					Sandstone	125	740
					Prairie du Chien series		
					Shale and caving rock	45	785
					Limestone	205	990
					Sandstone	20	1010
					Limestone	190	1200
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sand and shale	102	1302
Lockport city well	229[c]	Lo	23	568	Pleistocene system		
					Soil, sand and gravel	3	3
					Silurian system		
					Niagaran and Alexandrian series		
					Limestone	200	203
					Ordovician system		
					Richmond shale		
					Shale	87	290

[a] All wells more than 500 feet deep are herein considered deep wells. It is to be noted that shallow wells, Nos. 75, 175, 178, 187, 190, 230, 255, and 295 in Table 8 are deep enough to extend through the dolomite into other kinds of rock. Well No. 239 contains a valuable Pleistocene log, but the log of the solid rock cannot be correlated satisfactorily with the other well logs.

[b] T. E. Savage of the Illinois Geological Survey has made a study of samples from this well, and his interpretations are on file at the Survey. The log given here is that furnished by the driller. It seems certain that the samples studied by Professor Savage were incorrectly labeled as to depth by the driller, since the resulting log does not agree with other shallow and deep wells in the area.

[c] Anderson, C. B., Artesian waters of northeastern Illinois; Ill. State Geol. Survey Bull. 34, p. 222, 1919. It is to be noted that Alden, W. C., U. S. Geol. Survey Geol. Atlas, Chicago folio (No. 81), p. 2, 1901, gives a somewhat different log for this well.

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
					Galena-Platteville limestone		
					Limestone	245	535
					Limestone, brown, hard	95	630
					St. Peter sandstone		
					Sandstone	230	860
					Prairie du Chien series		
					Shale and red marl, "caves"	60	920
					Limestone, sandy	280	1200
					Limestone, hard	75	1275
					Limestone, sandy, and green shale	35	1310
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	220	1530
					Shale, sandy	110	1640
					Marl, red	80	1720
					Shale	150	1870
					Sandstone	52	1922
Dellwood Park well	237	Lo	26	645	Pleistocene system		
					Clay	18	18
					Silurian system		
					Niagaran and Alexandrian series		
					Limestone, soft	10	28
					Limestone, hard	472	500
					Quartz	10	510
					Ordovician system		
					Galena-Platteville limestone		
					Limestone, hard	237	747
					St. Peter sandstone		
					Sandstone	263	1010
					Prairie du Chien series		
					Clay, blue	11	1021
					Limestone, sandy	168	1189
					Clay, blue	21	1210
					Limestone, hard	32	1242
					Clay, blue	25	1267
					Limestone, sandy	13	1280
					Shale	6	1286
					Limestone, hard	48	1334

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.	*Feet*		*Feet*	*Feet*
					Clay, blue	10	1344
					Limestone	16	1360
					Clay, blue	5	1365
New Penitentiary Well No. 1 [d]	239	Lo	28	648	Pleistocene system		
					Clay, blue	54	54
					Sand and gravel	11	65
					Silurian system		
					Niagaran and Alexandrian series		
					Limestone	135	200
					Ordovician system		
					Richmond formation		
					Shale	80	280
					Limestone	100	380
					Shale	110	490
					Galena-Platteville limestone		
					Limestone, hard	340	830
					St. Peter sandstone		
					Sandstone	124	954
					Prairie du Chien series		
					Clay, blue	3	957
					Marl, red	7	964
					Limestone, red	11	975
					Sand, coarse	18	993
					Sand, white, fine	82	1075
					Sandstone, red	20	1095
New Penitentiary Well No. 2	240	Lo	28	642	Pleistocene system		
					Clay, yellow	20	20
					Clay, blue	25	45
					Gravel	6	51
					Limestone, soft (calcareous sandstone?)	3	54
					Sand and fine gravel	6	60
					Silurian system		
					Niagaran and Alexandrian series		
					Limestone, very hard	50	110
					Shale	7	117
					Limestone, soft and medium	138	255

[d] From comparison with other logs in the area this record appears unreliable; especially with respect to the Richmond formation

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
					Ordovician system		
					Richmond formation		
					Shale	115	370
					Galena-Platteville limestone		
					Limestone, hard	335	705
					St. Peter sandstone		
					Sand	130	835
					Prairie du Chien series		
					Shale, sandy near middle	45	880
					Limestone, sandy 1055-1105	525	1405
					Limestone, sandy near top	25	1430
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sand	110	1540
					Sand and limestone	16	1556
					Limestone	21	1577
Illinois Steel Company	261	Lo	34	552	Silurian system		
					Niagaran and Alexandrian series		
					Limestone	230	230
					Ordovician system		
					Richmond formation		
					Shale	68	298
					Galena and Patteville limestone		
					Limestone	334	632
					St. Peter sandstone		
					Sandstone	217	849
					Prairie du Chien series		
					Shale, red	40	889
					Limestone	450	1339
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sharp sandstone	175	1514
					Blue shale	50	1564
					Sandy limestone	125	1689
					Shale	230	1919
					Sandstone	150	2069

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
Williamson Avenue, Joliet	277	J	2	555	Pleistocene system		
					Till	10	15
					Silurian system		
					Niagaran and Alexandrian series		
					Dolomite	220	235
					Ordovician system		
					Richmond formation		
					Shale	80	315
					Galena-Platteville limestone		
					Dolomite	25	340
					Limestone	45	555
					Dolomite	30	585
					Limestone	65	650
					St. Peter sandstone		
					Sandstone	495	1145
					Prairie du Chien series		
					Dolomite	95	1240
					Sandstone	50	1290
					Dolomite	30	1320
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	268	1588
Canal and Division Streets, Joliet	300	J	9	532	Pleistocene system		
					Sand and gravel	3	3
					Silurian system		
					Niagaran and Alexandrian series		
					Dolomite, gray, fine-grained	227	230
					Ordovician system		
					Richmond formation		
					Shale, dark gray	90	320
					Galena-Platteville limestone		
					Dolomite, gray, fine-grained	300	620
					St. Peter sandstone		
					Sandstone	200	820
					Prairie du Chien series		
					Dolomite, gray, some sand	435	1255

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
					Sandstone, gray, dolomitic	25	1280
					(These last two samples have numerous specks of a dark mineral)		
					Dolomite, gray, some sand	50	1330
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone, gray, rounded grains	240	1570
Ruby and Canal Streets, Joliet	301	J	9	535	Silurian system		
					Niagaran and Alexandrian series		
					Dolomite, gray, fine-grained	180	180
					Ordovician system		
					Richmond formation		
					Shale, gray	80	260
					Galena-Platteville limestone		
					Dolomite, gray, crystalline	260	520
					Same, but with some sand	80	600
					St. Peter sandstone		
					Sand, white rounded quartz grains	80	680
					Same, but with some dolomitic cement	30	710
					Sand, white rounded grains	160	870
					Sand, pinkish rounded grains	60	930
					Sand, gray, some dolomitic cement	40	970
					Sand, pink	20	990
					Prairie du Chien series		
					Dolomite, some chert	20	1010
					Sand, white with a little dolomite	10	1020

TABLE 9—Continued

Name	No.	Location Twp.	Location Sec.	Elevation	Log	Thickness	Depth
				Feet		*Feet*	*Feet*
					Dolomite, gray, some chert and sand....	20	1040
					Shale, blue-gray, some dolomite	30	1070
					Dolomite, gray, with some white chert...	10	1080
					Shale, green-gray to pink, some dolomite	50	1130
					Dolomite, gray, fine crystalline, with pyrite and specks of a dark mineral in the lower part..	100	1230
					Dolomite, gray, some sand (some chert 1230-1270)	120	1350
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sand, rounded gray grains	130	1480
					Same with dolomite, shale and chert....	10	1490
					Shale, bluish green....	30	1520
					Dolomite, pinkish, finely crystalline	40	1560
Crowley Ave. and Ottawa Streets, Joliet	302[e]	J	9	533	Silurian system		
					Niagaran and Alexandrian series		
					Limestone, gray, fine-grained, dolomitic ..	218	218
					Ordovician system		
					Richmond formation		
					Shale	140	358
					Galena-Platteville limestone		
					Limestone, gray, dolomitic	360	718
					St. Peter sandstone		
					Sand, white, pinkish, and yellowish, fine to coarse rounded grains	410	1128

[e] See also Udden, J. A., Some deep borings in Illinois: Ill. State Geol. Survey Bull. 24, p. 40, 1914.

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
					Prairie du Chien series		
					Shale, mostly red, but also brown to black; partly dolomitic, but mainly non-calcareous, with some sand in the lower part	192	1320
					Limestone	73	1393
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sand, rusty to gray, somewhat angular grains	203	1596
					Shale, greenish-gray, with rusty streaks	31	1627
Fred Sehring Brewing Company, Scott and Clay Streets, Joliet	303	J	10	538	Pleistocene system		
					Clay, sand, and gravel.	?	?
					Silurian system		
					Niagaran and Alexandrian series		
					Limestone	?	222
					Ordovician system		
					Richmond formation		
					Shale, with streaks of limestone	107	329
					Galena-Platteville limestone		
					Limestone	361	690
					St. Peter sandstone		
					Sandstone	95	785
					Limestone, sandy	15	800
					Sandstone	42	842
					Prairie du Chien series		
					Limestone, sandy	20	862
					Shale, sandy	74	936
					Limestone	354	1290
					Shale	73	1363
					Limestone	62	1425
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	150	1575

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
Van Buren Street, Joliet	304	J	10	538	No record	190	190
					Galena-Platteville limestone		
					Dolomite	190	620
					St. Peter sandstone		
					Sandstone	300	920
					Prairie du Chien series		
					Limestone	30	950
					Dolomite	70	1020
					Shale and sand	30	1050
					Dolomite and limestone	280	1330
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	220	1550
Joliet Water Works, East Washington Street, Joliet	318	J	14	565	Pleistocene system		
					Gravel	36	36
					Silurian system		
					Niagaran and Alexandrian series		
					Limestone, very hard	312	348
					Ordovician system		
					Richmond formation		
					Shale, blue	90	438
					Galena-Platteville limestone		
					Limestone, gray, soft	330	768
					St. Peter sandstone		
					Sandstone	259	1027
					Prairie du Chien series		
					Limestone, bluish	269	1296
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	7	1303
Spruce Slip, Joliet	319	J	15	530	Silurian system		
					Niagaran and Alexandrian series		
					Dolomite	?	60
					Shale	10	70
					Limestone	130	200
					Ordovician system		
					Richmond formation		
					Shale	80	280

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
					Galena-Platteville limestone		
					Dolomite	230	510
					Limestone	180	690
					St. Peter sandstone		
					Sandstone	120	810
					Prairie du Chien series		
					Shale and dolomite	170	980
					Sandstone	120	1100
					Dolomite	135	1235
					Sandstone	55	1290
					Dolomite	50	1340
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	190	1530
Des Plaines Street, Joliet	320	J	16	540	Silurian system		
					Niagaran and Alexandrian series		
					Dolomite	60	60
					Limestone	140	200
					Ordovician system		
					Richmond formation		
					Shale	80	280
					Galena-Platteville limestone		
					Dolomite	210	490
					Limestone	140	630
					St. Peter sandstone		
					Sandstone	450	1080
					Prairie du Chien series		
					Limestone	230	1330
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	230	1560
Jasper Street Well, Joliet	321	J	16	540	Silurian system		
					Niagaran and Alexandrian series		
					Dolomite	190	190
					Ordovician system		
					Richmond formation		
					Shale	80	270

TABLE 9—Continued

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.	*Feet*		*Feet*	*Feet*
					Galena-Platteville limestone		
					Dolomite	325	595
					St. Peter sandstone		
					Sandstone	205	800
					Prairie du Chien series		
					Dolomite	435	1235
					Sandstone	120	1355
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	210	1565
Rockdale city well	335	J	20	548	No record	250	250
					Ordovician system		
					Galena-Platteville limestone		
					Dolomite, gray sub-crystalline	225	475
					Limestone, blue-gray, fine-grained, slightly dolomitic	40	515
					Dolomite, dark cream-colored, sub-crystalline	75	590
					St. Peter sandstone		
					Sandstone, rounded quartz grains up to .7 millimeters in diameter	70	660
Superior Alum Works	336	J	21	572	Silurian system		
					Niagaran and Alexandrian series		
					Limestone	185	185
					Shale	15	200
					Limestone	8	208
					Ordovician system		
					Richmond formation		
					Shale	135	343
					Galena-Platteville limestone		
					Limestone	447	790
					Shale, green	5	795

TABLE 9—Concluded

Name	No.	Location		Elevation	Log	Thickness	Depth
		Twp.	Sec.				
				Feet		*Feet*	*Feet*
					St. Peter sandstone		
					"Sandy lime and streaks of 'shale'"	60	855
					Sandstone	15	870
					Prairie du Chien series		
					Limestone	257	1127
					"Broken formation"....	23	1150
					Limestone	150	1300
					Shale, green, sandy....	60	1360
					Cambrian system		
					Croixan (Potsdam) sandstone		
					Sandstone	244	1604

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